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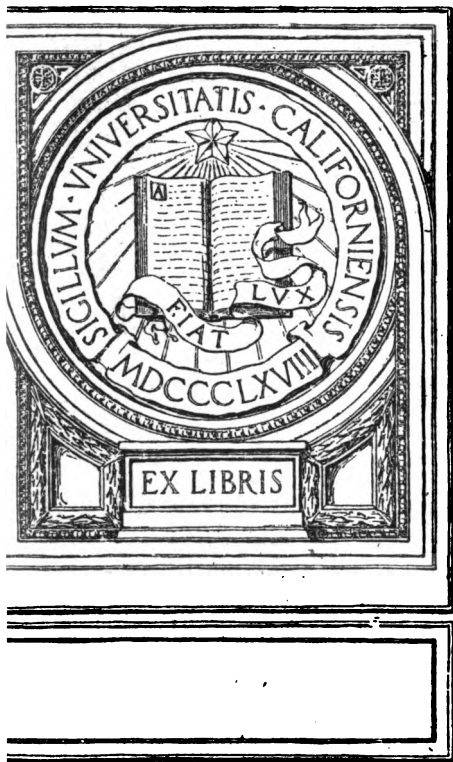
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HOUSE DRAINAGE AND SANITARY PLUMBING.

BY

WM. PAUL GERHARD,

Civil and Sanitary Engineer; Member American
Public Health Association.

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PREFACE.

THE essay reproduced herein was originally prepared for the annual report of the State Board of Health of Rhode Island. It was written both for professionals and laymen. Having met with a favorable reception it was thought worth while to increase its utility by republishing it in an improved and more accessible shape. Many parts were accordingly rewritten, others were modified and omissions corrected. Such omissions, however, are sure to occur in any edition of a book, containing descriptions of modern plumbing apparatus, as new appliances are continuously invented between the time the book is written until it is printed and published.

Many cuts of the original report have been omitted, particularly those illustrating plumbing fixtures, as these are contained in the well known catalogues and circulars of manufacturers of plumbers' supplies.

The author takes this opportunity to express his obligations to many friends for valuable hints and suggestions, which he has endeavored to embody in this improved edition. He would be glad if this little volume should prove to be of interest and value to architects, sanitary engineers, plumbers, sanitary officers and householders in general.

W. P. G.

NEWPORT, R. I., December, 1882

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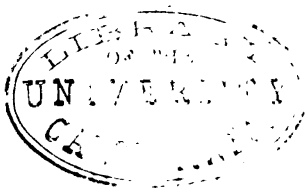
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House Drainage and Sanitary Plumbing.

MANY erroneous ideas still prevail about sewer gas and its danger to health which arises, by having so-called "modern conveniences" in our dwellings. It is the purpose of this paper, without in any way adding to the "plumbing scare," clearly to define wherein the danger consists, but at the same time to establish rules for the proper draining and plumbing of houses, which, if carefully observed, will secure to the anxious house owner work of superior quality and of a positively safe character.

Plumbing fixtures, which were considered a luxury years ago, are now believed to be necessary, not only for comfort and convenience, but also, and even more so, for health and for cleanliness. Even a small house is nowadays generally provided with a kitchen sink, a water closet, and sometimes a bath tub,

while in a costly modern residence, arranged with an elaborate system of plumbing, we find kitchen, pantry and scullery sinks, slop sinks, laundry tubs, stationary wash basins in closets near bedrooms, a great number of bath or dressing rooms, with water closets, urinals, bath and foot tubs, bidets and other fixtures.

The suggestions and recommendations of this report apply with equal force to the drainage and plumbing of tenements, small houses, costly residences, villas, apartment houses, hotels, factories, school-houses or public buildings. As every plumbing fixture is not only an outlet for the waste water to the drain, but possibly may become an inlet for drain air, the danger increases with the number of fixtures. A multitude of fixtures requires a large number of soil and waste pipe stacks, and the chance of leakage of sewer gas through defective joints increases correspondingly. But be the house large or small, its drainage and plumbing system should always be

so arranged as entirely to exclude any possibility of the escape of sewer gas.

SEWER GAS.

I shall, first, briefly consider what is meant by the term "sewer gas." This term, as Prof. W. Ripley Nichols has truly said,* is "an unfortunate one, and gives rise to a quite widespread but very erroneous idea. Many seem to suppose the 'sewer gas' to be a distinct gaseous substance, which is possessed of marked distinguishing characteristics, which fills the ordinary sewers and connecting drains, and which, as a tangible something, finds its way through any opening made by chance or by intention, and then, and only then, mixes with the atmospheric air."

Sewer gas is a mechanical mixture of a number of well known gases, having their origin in the decomposition of animal or vegetable matter, with atmospheric

* See Prof. W. Ripley Nichols' report upon chemical examination of the air of the Berkeley street sewer, in Boston, Mass., 1878.

air. This mixture is continually varying, according to the more or less advanced stage of putrefaction of the foul matters, which form a sediment and a slimy coating of the inner surfaces in drains and pipes. It is also variable with the character of this sediment or deposit, and with the physical conditions (moisture, heat, etc.) under which the decomposition takes place.

The principal gases found in sewers and drains are oxygen, nitrogen, carbonic dioxide, carbonic oxide, ammonia, carbonate of ammonia, sulphide of ammonium, sulphuretted hydrogen and marsh gas.

The three first-named gases are the principal constituents of the atmosphere, surrounding the globe, and are found present in the following *average* proportion, viz.:

20.9 vols. oxygen	} in 100 vols. of air, together
79.1 vols. nitrogen	
with 2 to 5 vols. carbonic dioxide in 10,000 vols. of air.	

According to R. Angus Smith the amount of *oxygen* is :

In the average, 20.96 vols. in 100 vols. of air.

In pure mountain air, 20.98 vols. in 100 vols. of air.

At the sea shore, 20.999 vols. in 100 vols. of air.

In streets of populous cities, 20.87 to 20.90 vols. in 100 vols. of air.

The air in sewers and drains contains much less oxygen, as some of it combines with the carbon of putrefying organic matter forming carbonic dioxide. The amount of nitrogen in the air of sewers is little different from that in the atmosphere which we breathe; but the amount of carbonic dioxide present is greatly increased.

The lowest amount of oxygen in sewer air is recorded to be 17.4 vols. in 100 vols. of air; the amount of carbonic dioxide is in the *average* 2.3 vols. in 100 vols. Sulphuretted hydrogen varies greatly, but the quantity is generally so small as not to be easily determined. Still more difficult is it to find by chemi-

cal analysis the proportion of other gases of decay.

In well ventilated and well flushed sewers, Dr. Russell, of Glasgow, found the following ratio:

20.70 vols. of oxygen in 100 vols. of air.

78.79 vols. of nitrogen in 100 vols. of air.

0.51 vols. of carbonic dioxide in 100 vols. of air.

No sulphuretted hydrogen in 100 vols. of air.

Traces of ammonia in 100 vols. of air.

Carbonic oxide is present only in excessively minute quantities, and even then it may have entered the sewer or drain through leakage of illuminating gas from gas mains.

In the absence of more satisfactory methods of analysis, it is usual with chemists to determine the amount of pollution of the air, or the organic matter in it, by determining the amount of carbonic dioxide present, assuming that there is a certain fixed proportion between the amount of carbonic dioxide

and the organic matter.* Thus, Prof. W. Ripley Nichols records as the average of many carefully conducted experiments in Boston, the amount of carbonic dioxide in a sewer in that city as follows:

The average of

- 31 determinations in January, 1878, was 8.7 vols. of CO_2 in 10,000 vols. of air.
- 44 determinations in February, 1878, was 8.2 vols. of CO_2 in 10,000 vols. of air.
- 47 determinations in March, 1878, was 11.5 vols. of CO_2 in 10,000 vols. of air.
- 12 determinations in April, 1878, was 10.7 vols. of CO_2 in 10,000 vols. of air.
- 8 determinations in June, 1878, was 27.5 vols. of CO_2 in 10,000 vols. of air.
- 8 determinations in July, 1878, was 21.9 vols. of CO_2 in 10,000 vols. of air.
- 6 determinations in August, 1878, was 23.9 vols. of CO_2 in 10,000 vols. of air.
- 7 determinations in January, 1879, was 8.0 vols. of CO_2 in 10,000 vols. of air.

* Such is strictly true only for air fouled by respiration, while it may not give accurate results in other cases.

In regard to this interesting question I must refer to the Report of Prof. Ira Remsen on the subject of organic matter in the air, published in the National Board of Health Bulletin, vol. 2, No. 11.

14 determinations in February, 1879, was 11.6 vols. of CO_2 in 10,000 vols. of air.

20 determinations in March, 1879, was 11.8 vols. of CO_2 in 10,000 vols. of air.

He remarks: "It appears from these examinations that in such a sewer as the one in Berkeley street, which, being of necessity tide-locked, is an example of the worst type of construction, the air does not differ from the normal standard as much as many, no doubt, suppose. In a general way, as we have seen, there is a larger amount of variation from normal air during the warmer season of the year; but even when the amount of carbonic acid was largest, it was only extremely seldom that sulphuretted hydrogen could be detected." "I think it should be said that the soil pipes and house drains are much more likely causes of discomfort and danger than the sewers."

Hence the importance of a thorough ventilation of all the soil, waste and drain pipes in a building.

Are the above-named constituents of

sewer air the origin or cause of the sickness so commonly attributed to the inhaling of sewer gas?

Although many of the gases named are poisonous, if inhaled into the system in large quantities, and may, even if present in smaller quantity, cause nausea, asphyxia, headache, vomiting, etc., none of them can be said to *produce* any of the so-called "filth diseases." To determine the exact origin of these is a still unsolved problem of physiology. While some believe that the particles of decomposing organic matter, present in sewer air and known as "organic vapor" cause disease, others seek the origin of the latter in microscopic *spores* or *germs* which live and feed upon such organic vapor and are capable of reproduction under favorable conditions, such as presence of putrefying filth, excess of moisture, heat, lack of oxygen, etc.

Whatever theory may be accepted as true, it is evident that, by preventing the decay of organic matter within sewers, drains and soil pipes, or by depriving

these germs (if such be the cause of disease) of the conditions facilitating their reproduction, we can best prevent the outbreak of excremental diseases. In other words, *by completely removing as speedily as possible all waste matters from the dwelling by pipes thoroughly and tightly jointed, and by a sufficient dilution of the air in these pipes with oxygen, the danger of infection, arising from defective drainage and plumbing, may be reduced to a minimum.*

It should be mentioned that some hygienists, notably Dr. Soyka and Dr. Renk, both assistants of Pettenkofer in Munich, have lately denied the existence of any positive proof of a connection between sewer gas and the spread of epidemic diseases—just as Naegeli and Emmerich doubt the possibility of infection from drinking water contaminated by sewage. Dr. Renk considers the exclusion of gases of decay from the interior of dwellings necessary only so far as they are offensive to the sense of smell. In this view, however, I cannot concur; in

regard to "filth-diseases," their causes and origin, I accept the theory of Dr. Simon, Parkes and others.

DEFECTIVE AND GOOD PLUMBING WORK.

The unhealthiness of dwelling houses has been greatly increased by plumbing work defective in design, materials and in workmanship, through ignorance, but often through intention of builders. The consequence was a growing inclination with some to abandon all plumbing fixtures, to go back to the ill-famed privy in the backyard, and to follow the practice of throwing the slops from the kitchen upon the grounds in the rear yard.

But, cannot this risk be avoided with careful, conscientious and honest workmanship, carried out under the strict supervision of an expert? Is it such a difficult thing to have a proper and judicious arrangement of the drainage system?

I shall endeavor in the following pages to explain what the elements of a well devised system of house drainage and sanitary plumbing are. Much has been

written of late about this subject. It has been well and thoroughly treated by able writers, and my paper can hardly claim much originality or novelty, but should be taken as the outgrowth of much study and experience.

The essentials of a perfect system of house drainage are simple and can be readily understood by any householder, when carefully explained. They involve nothing more than the proper application of well-known laws of nature; there is no mystery, no secrecy about any part of the work. Any one building a house is able to secure good drainage and a safe arrangement of the plumbing work without having to resort to any patented system. The proper way of laying and trapping drains, of ventilating soil and waste pipes, etc., cannot, in my judgment, be patented. The plumbing fixtures are, of course, mostly patented, as any useful appliance may be, and in speaking of these one cannot avoid recommending patented devices.

The entire sewage of the dwelling may

deliver either into a regular system of sewers, or else discharge into an open water course; or—in the absence of either—it may run into a cesspool, be it a leaching cesspool, or a well-cemented, tight vault of brickwork; or finally, into a flushtank, to be disposed of on the ground by surface irrigation, or below the ground by the subsurface irrigation system.

So far as the arrangement of the *inside* plumbing work is concerned, it does not make any material difference which of the above systems of getting rid of the waste-water from habitations is available.*

Under all circumstances the three cardinal objects to be fulfilled by a perfect system of house drainage are :

1. To remove from the inside of the dwelling as quickly as possible all liquid and semi-liquid wastes, whether it be the soapy discharge from wash bowls, bath tubs and laundry tubs, or the vegetable

* It is not intended in this paper to discuss the merits and faults of these different methods of sewage disposal.

refuse from the scullery sink, the greasy matter from kitchen and pantry sinks, or the foul discharges from slop sinks, urinals and water closets.

2. To prevent the foul gases originating from the decomposition of the above matters in the drain, sewer, cesspool or flushtank, from returning through the same channels into our dwellings.

3. To oxidize and render innocuous by a copious flushing with air the foul gases due to the possible putrefaction of waste matters within the house drains, soil and waste pipes, at the same time properly protecting all outlets of fixtures from the entrance of these gases.

DRAINS OUTSIDE OF THE HOUSE.

The house drain is the means for conveying the sewage from the dwelling. Its proper material is a question of great importance. Outside of the dwelling it should be of vitrified pipe, circular in shape, which is superior to cement pipe.

Iron pipe for outside drains is preferable in made ground, or in quicksand,

also where trees are near the line of the drain, and where the drain must necessarily pass near a well furnishing water for the household.

Neither brick channels nor wooden conduits should be used as house drains. Only strong, hard, well-burnt, vitrified pipe, free from cracks or other defects should be used. Four inch pipes and those of smaller size are especially liable to warping, and should be carefully inspected and selected. The interior of these pipes should be well-glazed and smooth throughout; the pipes should be impervious, true in section, perfectly straight, and of a uniform thickness. Four inch pipes should have a thickness of $\frac{1}{2}$ in. to $\frac{5}{8}$ in.; six inch pipes $\frac{11}{16}$ in. to $\frac{3}{4}$ in.; nine inch pipes should be not less than $\frac{3}{4}$ inches thick; 12 inch pipes should be 1 inch thick; fifteen inch pipe $1\frac{1}{4}$ in., and eighteen inch pipe should have a thickness of $1\frac{1}{2}$ inches.

The joints of the pipes should receive particular attention. The danger arising from imperfect or leaky joints is twofold,

{ namely, first, the sewage, by soaking into
 { the ground, pollutes the soil and endan-
 { gers the purity of the water supply in
 places where houses are dependent on
 wells and cisterns for water. The ground
 around and under the house is more and
 more subject to contamination, and in
 winter time, when there is a strong in-
 ward draft into houses from fireplaces
 and stoves, the tainted "ground air" is
 thus sucked into our very living and
 sleeping rooms, often producing severe
 illness. The second danger resulting
 from leaky joints is equally patent. The
 solid matters, carried in suspension in
 the pipes, are deprived of a part of their
 liquid carrier, and thus tend to accumu-
 late and form deposits in the house
 drain, which deposits soon undergo de-
 composition, and fill the drains and pipes
 with noxious gases.

Vitrified pipes are made either with a
 socket or hub attached to one end of the
 pipe, or with both ends plain. When
 socket pipe is used, special grooves
 should be cut in the bottom of the trench

for the hub, in order to give the pipe a solid bearing on its entire length. The pipes are laid with the socket pointing upgrade, the plain or spigot end of one pipe being inserted into the socket of the next. Spigot and socket ends should be concentric. Into the annular space between both a gasket of picked oakum is introduced and firmly rammed by a hand iron. The remainder of the space is then filled with pure cement, or cement mixed with an equal volume of sand. No lime should be used with the mortar, which should be prepared only in small quantities at a time, to prevent its setting before use. Particular attention should be given to the bottom part of the joint, where the mortar should be pressed into it with the fingers. If water accumulates in the trench, this should be carefully removed from the grooves before making the joints, and sufficient earth should be thrown into the groove to support the mortar at the bottom of the joint, until it has time to harden. The gasket of oakum prevents any cement from

projecting into the inside of the drain, and renders the use of a rattan and rag, with which to wipe the inside of joints, unnecessary. Where the sockets are insufficient in length to permit the use of a gasket, it becomes important to clean the joints of cement projecting at the inside, but in this case a better device than a rattan with rag tied to it is a strong handle to which is attached a semi-circular disc of wood, of a somewhat smaller radius than the radius of the pipe.

The cylindrical pipe without sockets is preferred by some. The joints, in this case, are made by butting two pipes together, and covering them with rings or collars of unglazed terra cotta,*applying cement to the inside of the collar and to the ends of the pipes.

Some object to the use of cement for drain pipe joints, claiming that the stiffness of the cement joint after hardening will tend to break the pipes in case of a slight settling. They also maintain that some cements increase considerably in

volume when setting, and tend to burst the sockets. They much prefer a ring of puddled clay, pressed into the joint and wiped around it, claiming that clay will make a tight and more elastic joint. But in ordinary cases the settling of drain pipes may be prevented by providing a solid foundation of either gravel, sand, or concrete, or in very wet ground, boards or piles as supports to the pipe. In made ground I should recommend the use of iron pipes to prevent leaky joints or breakage of pipes. A good Portland cement will not much increase in volume after setting, and I believe it has been shown that those cements which largely increase their volume, often lose their hardness after some time, and would be, therefore, unfit for any use. While I fully appreciate the advantage of a somewhat elastic joint, I do not think that puddled clay will make as tight a joint as seems desirable for drains carrying foul sewage.

What is known as "Stanford's Improved Pipe Joint" has been used exten-

sively of late in works of house drainage in England, and its superior merits are such as to recommend it for use with us. I, therefore, introduce a brief description. "In sewer work in bad or wet ground, just where a sound joint is most required, the difficulty of making it is the greatest. What is wanted, therefore, is a joint that will entail the least disturbance of the ground, that will not necessitate the absolute drying of the trench bottom, and that will require the minimum of time, skill, and labor in making it. These conditions will be fulfilled in the most complete manner by making the spigot of one pipe to fit mechanically into the socket of another, as in a bored and turned iron pipe joint. Such a mechanical fit cannot be obtained with stoneware or earthenware pipes, owing to the difficulty of preserving perfect accuracy of form during the process of burning."

"In the Stanford joint tightness is obtained by casting upon the spigot and in the socket of each pipe, by means of

moulds prepared for the purpose, rings of a cheap and durable material, which, when put together, fit mechanically into each other, and by making these rings of a spherical form, a certain amount of movement or settlement may take place without destroying the accuracy of the joint. In laying these pipes, therefore, all that is necessary is to insert the spigot of one fairly and firmly into the socket of another previously laid, and the joint is complete and perfectly watertight. A smearing of some kind of grease is frequently found to be of advantage."

Half socket or access-pipes are sometimes useful, where it becomes necessary often to inspect the house drain. They should be located close to angles, bends, junction branches, running traps, &c. They are not much used in this country, owing, probably, to the fact that, should the main drain run over one-half full, sewage may leak out through the access-pipes into the soil.

Care should be taken to lay the pipes

on a firm bed of sand or gravel, and if this is not available, a concrete base should be provided in the trench. The pipes should be laid in straight lines, all changes of direction should be effected by curves of as large a radius as possible, formed of bent pipes. All branches should join the main under an acute angle, by special Y pieces, for a right-angled junction (by a T branch) tends to form eddies and consequently deposits in the main drain.

In laying drains, care should be taken to avoid, as much as possible, trees. The roots of these are frequently found to penetrate and often choke the pipes, and are certainly a dangerous obstruction to the flow in the drain. If the line of the drain must necessarily pass near trees, the use of iron pipes is recommended. The coating of the pipes with coal tar on their outside, the use of asphaltum for joints, and sometimes the surrounding of the drain with a strong layer of concrete are said to be effectual protections against roots of trees.

I now must speak of the *grade of the drain*, as this is a matter of prime importance. Upon the inclination of a pipe depends the *velocity* of the water flowing through it. If this velocity should be insufficient, deposits will occur, and the drain will in time become choked. Pipes of 4 inches diameter should have a velocity of flow of from 3 to $4\frac{1}{2}$ ft. per second; those of 6 and 9 inches diameter should have a velocity of not less than $2\frac{1}{2}$ to 3 ft. A velocity of 2 ft. per second should be considered the minimum allowable in house drains. As a general rule the inclination of a house drain should be as great as attainable, and must be, wherever local conditions will permit, continuous. It is not unfrequently found by uncovering old drains that, in order to save digging, they are laid very flat, often perfectly level, from the point where they leave the house to nearly their junction with the sewer, at which place they are turned with a steep pitch downwards, and often enter the sewer at its crown.

By distributing the whole available fall over the total length of the drain a much better grade would have been secured.

In order to lay a drain with a true grade, especially where the fall is little, a level should be used. The elevation of bottom of pipe, where it leaves the house—at a depth of not less than 3 feet in the New England States, as a protection against frost—should be ascertained, as well as the elevation of the junction with the sewer (or else inlet to cesspool or flush tank). A profile of the ground along the line of the drain should also be determined by levelling. Thus, the proper available fall can be determined, with a little additional trouble, it is true, which, however, will be well repaid by securing a much better quality of the work.

A fall of from 1 in 40 to 1 in 60 is desirable for pipes of 4 or 6 inches diameter, but this cannot always be had. I would consider a grade of 1 in 100 as the least to be given to house drains, in

order to keep them self-cleansing. When laid with such fall and running full or half-full, a six-inch drain has a velocity of $3\frac{1}{2}$ feet, a four-inch drain a velocity of nearly 3 feet, which is sufficient to carry along such suspended matters as only ought to enter a house drain. Where the available fall is less than 1 in 100, special flushing apparatus, such as Field's flush tank, McFarland's tilting tank, or Shone's hydraulic syphon ejector should be used.

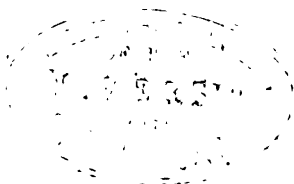
I have thus fully explained the right method of laying drain pipes, because, even with the best plumbing inside of the house, it is of the greatest importance to have the outside drains of good quality, properly laid, and properly jointed.

The next question to be considered is: *What is the proper size for house drains?*

This will, of course, depend to some extent upon the grade of the drain, the size of the house and number of its occupants, the amount of water used per head per day, and finally, unless the rain

falling upon the roof is stored in a cistern, upon the amount of rainfall to be carried off in a certain time. This rain is a most beneficial scourer for drains, and unless the sewage of the dwelling is to be disposed of by irrigation, or the sewers of the town built according to the "separate system," which excludes the rain-fall from the channels carrying sewage, I should strongly advise to deliver it into the same channel, which carries away the foul wastes of the habitation. Even with this double purpose in view the house drain need not be very large, and the closer its size is proportioned to the volume of water it must carry the more *self-cleansing* will it be.

To illustrate the advantage gained by reducing the size of drains as much as possible, or in other words by concentrating the sewage flowing through it, I have constructed the diagram, Fig. 1, which represents for different depths of flow in the same pipe the change of velocity. It is evident that the velocity in a pipe will greatly diminish as the depth of the



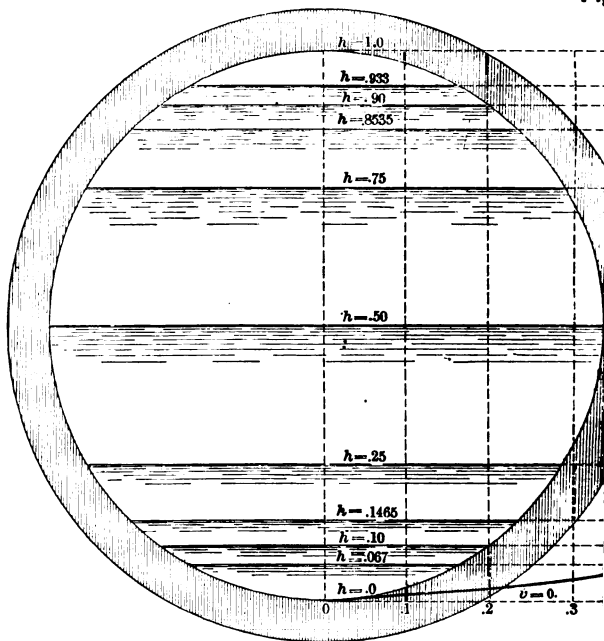


DIAGRAM REPRESENTING CHANGES OF VELOCITY
LAID AT A GIVEN GRADE, λ

Velocity when running full = 1

$v = 1.0794$ Velocity when running full

$v = 1.0918$ " " "

$v = 1.1010$ " " "

$v = 1.0984$ " " "

$v = 1.0$ " " "

$v = .7658$ " " "

$v = .6028$ " " "

$v = .504$ " " "

$v = .416$ " " "

Curve indicating change of velocity

IN A CIRCULAR SEWER OF THE DIAMETER = 1,
DIFFERENT DEPTHS OF FLOW.

stream flowing through it diminishes. The diagram shows that the velocity is the same for drains running full or half full; it also shows that the maximum velocity of flow occurs not when the sewer is running full, but when the depth of flow is about .813 of its diameter. The maximum velocity is about 11 per cent. greater than that of a pipe running full or half full. The maximum discharge, however, does not coincide with the maximum velocity. The discharge is a maximum when the depth of flow is about .95 of the diameter. At a depth of flow of one fourth of the diameter the velocity is only about 77 per cent. of that when running full or half full, and for lesser depths of flow it diminishes rapidly.

For an ordinary city dwelling a drain four inches in diameter is ample, even including all the rain-fall. For a larger lot and residence a six-inch drain is all that is needed, even if the fall should be only 1 in 100. As a general rule, house drains have been constructed of too large

a diameter, and one often meets with the objection that a four-inch pipe will clog up with grease in a short time, or will be obstructed by solid substances. To this, I answer, that in regard to grease the only safe way, where it is allowed to waste, or in case of large boarding-houses and hotels, is to keep it altogether out of the drain (which can be easily accomplished by a suitable grease trap). Grease congealing in a drain is sure to clog it, no matter how large it is made. The stoppage would be only a question of time, and nothing could be gained by postponing this inevitable result. In regard to obstructions by solid matters, I may assert that nothing which passes through the strainer of a sink or from the water-closet bowl can possibly obstruct the drain. What may enter through carelessness of servants, or of the householder, such as "sand, shavings, sticks, coal, bones, garbage, bottles, spoons, knives, forks, apples, potatoes, hay, shirts, towels, stockings, floor-cloths, broken crockery, etc.," to quote

from Mr. J. Herbert Shedd's Report on the Sewerage of Providence, cannot rightfully be expected to be carried away in a drain. To guard against such obstructions, the drain should be made accessible, especially near bends, junctions and the main trap.

The following useful table, calculated by Robt. Moore, Esq., C.E., from Weisbach's formula for flow of water through open culverts, gives the size and velocity in house drains, laid at different inclinations, and for various sizes of lots, the rain-fall being 2 inches per hour, and the pipes running $\frac{3}{4}$ full. It should be said that the smallest sizes of the table (below 3 or 4 inches diameter) are given only for the sake of completeness, and not as sizes to be recommended for actual use.

Take, for example, an ordinary city lot of 25×150 ft. = .0861 acres. The rain-fall to be provided for may be 2 inches per hour. Though such storms are not frequent, provision should be made for them in the calculation of the size of house drains, as the rain falling on roofs

that rain gets into the sewer
at the same time ^{raining} as a cloud burst
comes down a canyon.

and on paved yards reaches the drain
very soon after having fallen. A rainfall
of 1 inch per hour per acre very nearly
yields 1 cubic foot per second, therefore
2 inches per hour give 2 cub. ft. per sec.
per acre. The number of cubic feet of
rain from the above lot is therefore .0861
 $\times 2 = .1722$ cub. ft. per second or $60 \times$
.1722 = 10.332 cub. ft. per minute.

We further assume 6 persons to the
house, and 75 gallons per head per diem,
which is a very liberal allowance. The
waste water of the house is therefore 6
 $\times 75 = 450$ gallons per day. If one-
half of this amount is estimated to run
off in 8 hours, the maximum per hour
would be about 28 gallons or .0624 cub.
ft. per minute. This quantity is so in-
significant compared with the rainfall
that we may safely neglect it.

Should the drain be allowed to run
three-quarters full, and have a fall of 1
in 100, a diameter of $3\frac{3}{4}$ inches would
suffice, according to above table.

As a second example, I shall take a
large lot, say 80×150 ft. = .2755 acres.

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The quantity of rain to be discharged will be, under the same suppositions as above, $2 \times 60 \times .2755$ acres = 33.06 cub. ft. per minute. For a drain, running $\frac{3}{4}$ full, the table gives the necessary diameter = $5\frac{1}{4}$ inches.

For a convenient graphical exhibit of the relation between inclination, size, velocity and discharge of drains and sewers see the author's "Diagram for Sewer Calculations," 1881, N. Y.

The foregoing explanations have, I believe, sufficiently proved that *no house drain needs to be larger than six inches* under ordinary circumstances, while in most cases a 4-inch pipe will fully answer the purpose. Any increase of size would tend to be a detriment rather than a benefit.

DRAINS INSIDE OF THE HOUSE.

The earthenware drain should end at about 5 to 10 ft. outside of the foundation walls of the house. From this point towards the inside of the house the drain should be of iron. The joint

between iron drain and earthenware pipe should be made with pure hydraulic cement. Where the iron pipe passes through the wall, a relieving arch should be built over it. Settlement of walls often occurs, and is liable to crack the pipe or even break it, unless the above provision is carried out. It is quite evident that, under no circumstances whatever, this part of the house drain should consist of vitrified pipe.

Important as it is to have the drains outside of the house free from sediment or leakage, it is still more so to have all the pipe joints inside of the dwelling perfectly air and water tight, for if any defect should exist here, sewer gas will leak into the cellar and pervade the whole house. For this reason we sometimes find the cardinal rule laid down that no drains should run under a house, but should be taken outside of it as soon as possible. This is not practicable, as a general rule, in the case of narrow city lots. Fortunately, however, we can, with perfect safety, run the drains across the

basement or cellar floor of a dwelling, provided we choose the only safe material, i. e. *iron pipes*. A good mechanic is able to make with these a perfectly air and water tight joint.

The best course of the iron drains in the house is along the ceiling of the cellar, or along one of the foundation walls. In other words, wherever practicable, the iron drain ought to be kept *in sight*, in order to enable anybody to detect a leaky joint at occasional inspections. Sometimes fixtures located in the cellar, such as servants' water closets, laundry tubs or sinks, make it necessary to lay the iron drain below the cellar floor. In this case it should be laid with proper fall in a trench, the sides of which are walled with brick work, and the base of which should consist of a layer of from 4 to 6 inches of concrete, thoroughly rammed and properly graded. The trench should be made accessible by closing it with movable covers of iron or wood.

If the drain is carried in sight, I would much prefer supporting it by strong iron hooks from the cellar wall, or by brick piers, where the ground is solid, and not liable to "settle," instead of suspending it by iron hangers from the main joists of the floor above. For, with the latter arrangement, a slight lowering or bending of the beams supporting the iron drain, would tend to loosen the joint between water closet trap and soil pipe, as the latter is rigidly connected with the drain, thus creating a source of danger from leakage of sewer gas.

As regards the proper inclination of iron drains in the cellar, the rules given for the outside drains should be observed.

The principles stated for the size of the outside drain apply with equal force to the inside drain. If no leaders enter the drain at its upper end or along its course through the house, a 4-inch pipe is ample for any ordinary sized dwelling; a 6-inch drain is very seldom required.

As a good precaution for repairs or cases of obstructions of the drain, I would recommend the practice of many plumbers, which consists in inserting at distances of about 10 or 20 feet along the course of the iron drain Y branches, the ends of the branches being closed by a brass thimble, caulked into the hub of the Y, and closed by a trap screw. By opening these and inserting a proper cleaning tool, occasional obstructions by introduction of foreign matters are easily removed.

The course of the main drain in cellar should be as straight as possible. All changes of direction should be made by iron bends. All junctions with the main drain should be made by Y branches, in order to join the flow of both pipes without causing eddies; no right-angled junction should be made in any horizontal or inclined pipe.

SOIL AND WASTE PIPES.

Into the iron drain the vertical soil and waste pipes enter by means of either

quarter bends or by a Y branch with an eighth bend.*

* As regards the exact meaning of the terms drain pipe, soil pipe, and waste pipe, I quote the following clear explanation from the "Sanitary Engineer," Vol. 4: "The drainage system of a house, including the pipes or channels of any kind connecting it with the sewer or cesspool, may be divided into two parts—first, that part which is chiefly outside the house walls, and second, that which is generally inside the house. The first is called the *house drain*, or simply *drain*, and conveys the whole body of wastes from the house, including both the discharges from water-closets and urinals, and from baths, basins, sinks, &c., to the sewer or cesspool. The *drain* is practically *horizontal*, and may be considered as terminating either at the house wall, or at the most remote point at which it receives the pipes from any fixtures. The word *drain* is, however, also used in another sense as distinguished from *sewer*. It then means the pipe or channel which conveys only rain or ground water, as distinguished from sewage. An example of this kind of drain is the separate system of pipes, used to convey only rain water in some towns and the tile pipe commonly employed in draining wet lands.

"That part of the house drainage system which is generally inside the house, including the pipes from the various fixtures, is made up of *soil pipes* and *waste pipes*. *Soil pipes* are those pipes which receive *human excreta* from water closets and urinals, and they are still called soil pipes, even if they also receive the waste water from baths, basins, &c. On the other hand, *waste pipes* are those which receive *only* the waste water from these latter, but not the discharge from water closets and urinals. The *waste pipes* of a house may either enter the *house drain* independently

The best material for soil and waste pipes is cast iron. All cast iron pipes used in house drainage should be thoroughly sound, of a *uniform* thickness throughout, and must allow of ready cutting without splitting. The inside should be truly cylindrical and of smooth finish. The thickness of ordinary (so-called *light*) soil pipe is about $\frac{1}{8}$ of an inch for 2, 3 and 4-inch pipes, and $\frac{5}{32}$ to $\frac{3}{16}$ of an inch for 5 and 6 inch pipe. For all large public or private buildings I should always insist upon the use of *extra heavy* soil pipe, which is about double as thick as the ordinary pipe. The weights of extra heavy pipe are about as follows:

2 inch pipe,	5½ lbs. per foot.
3 inch pipe,	9½ lbs. per foot.
4 inch pipe,	13 lbs. per foot.
5 inch pipe,	17 lbs. per foot.
6 inch pipe,	20 lbs. per foot.

or join the *soil pipe* first and discharge their contents through it into the *drain*. As distinguished from the *drain* the *soil pipes* and *waste pipes*, at least for the longer lengths, are generally vertical."

Great care should be exercised by plumbers, architects, plumbing inspectors and sanitary engineers in regard to the *uniform* thickness of iron soil pipe. The writer has lately seen specimens of extra heavy soil pipe where the pipe was almost as thin as a knife-blade on one side, while it had far more than the required thickness on the other side, the weight being as specified. Measuring the thickness of iron drain pipes by a pair of calipers should be recommended, but I am not aware that it is done at all now.

Iron soil pipe, the inside of which has been made smooth by dipping the pipe into a hot solution of coal-tar pitch, is superior to ordinary iron pipe. This coating, when applied to the outside of the pipe, forms a good preventive against rust or corrosion, and is better than any paint applied to the iron. Where economy is no object, the *enamelled* pipe may be used, which has a very smooth inside surface, thus securing to well-flushed soil pipes the greatest pos-

sible cleanliness. Whether iron pipes are coated with coal-tar pitch or enamelled, it is necessary, before applying either of these protective coats, carefully to test each pipe for defects, sand holes or cracks, by the hammer test. The coating may effectually cover these defects and render detection difficult.

Iron pipes are manufactured in lengths of 5 feet, with hub and spigot end, or else with double hub.

The iron works manufacture not only straight soil pipe, but a large number of fittings, such as quarter bends, eighth bends, sixth bends, sixteenth bends, T branches, Y branches, double Y branches, half Y branches, offsets, single and double hubs, increasers, reducers, &c., to enable the plumber to make all possible connections and lines with iron pipe.

In England *lead pipe* is preferred for soil pipes. According to one of the best English authorities on plumbing*

* S. Stephens Hellyer, "The Plumber and Sanitary houses," 2d edition.

the advantages claimed for lead pipe are briefly as follows:

1. It is smoother, cleaner, not so corrosive; more durable.

2. It can be bent to suit any position; it is more compact.

3. Its joints are more to be depended upon than iron pipe joints.

4. Urine, being very corrosive, acts more on iron than on lead.

5. Iron pipe rusts on the outside, and painting iron pipes, to prevent it, is expensive, and is generally not done thoroughly at the back of the pipe.

6. Lead branch wastes or traps cannot easily be joined to iron pipe.

7. Iron pipe does not allow caulking joints with lead, therefore cement is used for the joint.

From all this I disagree, for:

1. Tarred or enamelled iron pipe is fully as smooth as lead pipe, and the iron pipe is thereby well protected from corrosion.

2. The above enumerated variety of special fittings enables the plumber

readily to adapt his iron pipe to almost any position; moreover I do not see why iron pipe should take up a great deal more room than lead pipe of same bore.

3. *Well caulked* joints of heavy iron pipes are just as sound and trustworthy as wiped joints in lead pipes, and any good mechanic is able to make them.

4. Urine does not corrode an iron soil pipe, protected by a coal-tar pitch solution or by enamel, more than a lead pipe.

5. The outside of iron pipe can be efficiently protected from rusting by paint, coal-tar pitch or enamel.

6. Lead cannot be caulked into iron, but a good plumber always solders a brass ferrule by a wiped joint to the lead pipe (or trap), and caulks the brass ferrule into the hub of the iron pipe.

7. Any one who will take the trouble carefully to examine the joints of iron pipe, made by an honest and conscientious plumber, will readily admit the possibility of making tight joints with iron

pipe. Only iron pipe of a sufficient strength to withstand the knocking occasioned by caulking the lead is used in American plumbing.

But, while iron pipe is fully equal in all the above respects to lead, it has great advantages over it. "Lead soil pipes are very heavy, and, therefore, liable to sag and split open, to have holes eaten into them by rats, and have nails driven into them by carpenters, and also to corrode, and they require much greater skill to put up, and involve more expense; therefore the statements of Hellyer prove nothing, although they demonstrate the absurdity of bricking soil pipes into a wall, and the necessity of so placing them that they are at all times readily accessible for inspection; and also prove what few people seem to realize, that the drainage system of a house requires periodical testing and inspection just as much as a steam boiler or piece of machinery." *

* See articles on "Plumbing Practice," in the Sanitary Engineer, vol. 4.

Pipes of wrought-iron, coated with coal-tar pitch, have been lately used for soil pipes, notably in the Durham system of house drainage. I am not prepared to say whether or not such pipes last as long as cast-iron pipes protected with the same coating.

Soil pipes should not, as a rule, be larger than four inches inside diameter; this size will answer for half a dozen or more water closets on one vertical stack of pipe. From a late account of the sewerage of the city of Pullman, near Chicago, I learn that several hundred soil pipes of 3-inch bore were used in the houses, and "in the case of three-story flats, one pipe frequently has six closets connected to it." Very few instances of stoppage occurred, and these were always "due to obstructions that got in during construction, and never to the use of a small-sized pipe." Such a reduction of the size of soil pipes will undoubtedly increase the danger of "siphonage of traps," and for this reason it is

hardly safe to use soil pipes smaller than four inches inside diameter.

Waste pipes of iron should be $1\frac{1}{2}$ or 2 inches in diameter. This is ample for the waste water of one or more bath tubs, and a large number of wash bowls.

I may here remark that, contrary to the generally entertained opinion, a nearly horizontal or inclined pipe can be kept clean by flushing much easier than a vertical pipe. The flushing water in this latter case soon assumes a whirling motion, and the scattered drops fall downward without exerting much scouring action upon the interior of the pipe. Hence the importance of having the inside of soil and waste pipes as smooth as possible to prevent solid matters from adhering to the sides, where hardly any amount of flushing will take them off.

The arrangement of soil and waste pipes should be as direct as possible. It is desirable that each vertical stack should extend from cellar to roof in a straight line. In planning the plumbing

for a dwelling too much care cannot be taken to secure such an arrangement. Every offset, every bend in the pipe forms an obstruction to its proper flushing, with both water and air. Horizontal soil pipes are especially objectionable; the water closets, baths, bowls and sinks should always be located in groups, and as near to their respective pipes as possible.

It is desirable to run soil pipes and waste pipes in sight, so that they may be accessible. I decidedly condemn the usual plan of architects of building recesses or niches in the walls for pipes. The difficulty of caulking the back part of pipe joints in this position is very great. Where objection exists to having the pipes in sight, they should be boxed up, but I would always insist upon having the cover fastened by screws, which can be easily removed, and not by nails.

Iron soil and waste pipes should be supported at distances of not over five feet by strong iron hangers or hooks.

Branch pipes should enter the vertical

stack by means of a Y or half Y branch, wherever possible ; a right-angled junction, by a T branch, is not so objectionable here as in the case of horizontal or inclined pipes.

In badly drained houses, with cheap plumbing work, it is not uncommon to find the joints of pipes made only with sand and paper, or with putty, mortar, cement, sulphur and pitch and red lead, or other material. All of these joints are worthless, and therefore extremely objectionable.

Joints of iron pipe should be made by first inserting a little picked oakum into the socket, care being taken that no part of this gasket enters the pipe. The oakum prevents the molten lead from running into the pipe, where it might form an obstruction to the flow. Molten lead is then poured into the hub, enough quite to fill it. As lead shrinks in cooling, it must afterwards be carefully hammered with a special caulking tool, thus filling the space between spigot and hub, so as to make a perfectly gas and water

tight joint. In order to be able, at all times, to inspect the joints, it is a good practice to leave the caulked lead without a cover of paint, cement or putty, the marks of the caulking tool being thus left exposed to view.

A tight joint can also be made with a mixture of sal ammoniac, iron filings and sulphur. Such "rust joints," however, are not much used for soil pipes.

Where wrought-iron is used for soil and waste pipes, the joints are screw joints, and can be made tight as in steam fitting work.

When all the iron piping in the house is completed, the tightness of the joints should be thoroughly tested, before connecting the fixtures. The test which is mostly used, is the "water pressure test." The end of the iron pipe outside of the foundation walls is tightly closed by a wooden plug, or better, a disc of india rubber, which can be squeezed between two iron discs. All branches of soil pipes and waste pipes are similarly closed. The pipes are then filled with water, which

must stand in them for some time. If the subsequent inspection shows a lowering of the water level, there must be a leak at some joint, or else some defect exists in the iron piping. Of course the leak must be found and repaired, and the test should then be repeated, until all joints are water and air tight.

An equally reliable pressure test is made by using a force pump and a manometer.

For occasional inspections of old plumbing work, and in making sanitary examinations of houses the "peppermint" and the "smoke test" become useful. The peppermint test is thus described: "When called on to detect a leak in the soil pipe of a house, the plumber goes at once to the roof, if the soil pipe be carried above the roof; if not, he goes to the uppermost water closet, and pours into one or the other something like an ounce of peppermint, and follows it up with enough water to insure its being carried the full length of the soil pipe. (The top of soil pipe should be closed, in or-

der to prevent the oil from escaping into the outside air.) "Another man then traces the soil pipe from the bottom, throughout its course; knowing that if there is any crevice through which sewer gas can enter, the pungent odor of the volatile essential oil will be readily perceptible even in the presence of odors of a baser kind. Great care must be taken not to carry the peppermint about the house, otherwise the smell cannot be traced to the drains."

Captain Douglas Galton describes another test thus: "To test the drains the fumes of ether or of sulphur may be used. If ether is poured down a soil pipe the fumes will be perceptible in the house at any leaks in the soil pipe or failures in the traps. Sulphur fumes may be applied by putting into an opening made in the lowest part of the drain an iron pan containing a few live coals, and throwing one or more handfuls of sulphur upon the coals, and closing up the opening to the drain with clay or otherwise. The fumes will soon be very perceptible

at any leaks or rat holes in the soil pipe, drains or traps."

The connections between fixtures and the soil or waste pipes are made with lead pipe, which can easily be handled, and may be bent and cut to suit all possible positions, and requires but few joints. It is manufactured in long coils, of all sizes and of any desired thickness. In good plumbing work only heavy lead pipe should be used to prevent its being quickly destroyed by the corrosive action of sewer gas. It is desirable that lead pipe should be used as little as possible in *concealed* places, as it may be gnawed by rats or split by nails through carelessness of carpenters.

It is not uncommon to find vertical waste pipes of lead, as these are easily placed inside of a partition and covered with plaster. But this cannot be regarded as good practice; iron for waste pipes is decidedly to be preferred.

Vertical lines of lead pipe should be fastened to boards by soldering hard metal tacks to the pipe and screwing

the flanges of the tacks to the board. Horizontal lines should be continuously supported on boards between joists.

Lead pipes are mostly joined by what is called a "wiped joint." The end of one pipe is flanged out so as to form a cup, into which the other pipe, the end of which should previously be sharpened, is introduced. Hot solder is then applied to the joint, and wiped around it so as to form an oval lump.

Where lead pipes are joined to iron pipe, the connection should be effected by means of a brass ferrule of the same bore as the lead pipe, and soldered to it, wherever space allows, by a wiped joint. The ferrule is introduced into the hub of the iron pipe, and caulked tightly with a gasket of oakum and molten lead.

The size of lead waste pipes should be as small as is consistent with the office which they have to perform. Wastes for bath tubs or laundry trays should be sufficiently large to empty these vessels in a short time.

The following sizes of waste pipes for fixtures should be recommended :

For wash basins.....	$1\frac{1}{4}$	inches diameter.
For wash basin overflows..	$1\frac{1}{4}$	“ “
For bath wastes	$1\frac{1}{2}$	“ “
For bath overflows.....	$1\frac{1}{4}$	“ “
For wash tub wastes.....	$1\frac{1}{2}$	“ “
For kitchen sink wastes ..	$1\frac{1}{2}$	“ “
For pantry sink wastes ...	$1\frac{1}{4}$	“ “
For slop sinks.....	$1\frac{1}{2}$ to 2	“ “

Local conditions will, in some cases, demand a deviation from these sizes.

ESSENTIAL ELEMENTS OF A SYSTEM OF PLUMBING.

WE have thus far considered only the material, size, general arrangement and manner of jointing the drain, soil and waste pipes in a house. We must now consider what the essentials of the system are, in order to secure to the house perfect immunity from sewer gas. Briefly stated, these essentials are as follows :

1. *Extension of all soil and waste pipes through and above the roof.*

2. *Providing a fresh air inlet in the drain at the foot of the soil and waste pipe system.*

3. *Trapping the main drain outside of the fresh air inlet, in order entirely to exclude the sewer air from the house.*

4. *Providing each fixture, as near as possible to it, with a suitable trap.*

5. *Providing vent pipes to such traps under fixtures as are liable to be emptied by siphonage.*

EXTENSION OF SOIL AND WASTE PIPES.

The *first* requirement asks for a vertical extension of all soil and waste pipes through the roof. This extension affords a ready outlet for all gases that would otherwise tend to accumulate inside the pipe system. In the case of soil pipes nothing short of an extension the *full bore* of the pipe will answer this purpose. It has been proposed, of late, to enlarge the soil pipe from the highest floor to the roof to six inches diameter, in order completely to prevent any stagnation of air in the pipe. Waste pipes should be

enlarged from the point where they pass through the roof, to four inches diameter, as smaller outlets are liable, in cold climates to become obstructed by the freezing of condensed vapor. Plumbers sometimes use galvanized wrought iron or tin pipes for this extension, but this is decidedly bad practice. It should be of the same material as the main soil pipe, and its joints should be worked with equal care.

The extension of soil and waste pipes should terminate at a distance from any windows, louvred skylights, or ventilating flues, and at least two feet below the top of the nearest chimney. It is desirable to have this extension as high as possible above the roof, so as well to expose the mouth of pipe to the influence of air currents. In order to prevent any obstruction of the soil pipe, plumbers often cover the mouth with a return bend. This, however, is objectionable, as it interferes with proper ventilation. Less bad is the plan of capping the soil pipe with a suitable fixed cowl, such as, for instance, Emerson's or Wolpert's ventilator. The

best plan seems to be to do away entirely with any cover to the soil pipe mouth. Capt. Douglas Galton, in his book "Construction of Healthy Dwellings," says in regard to this question: "A tube or shaft with an open top acts best. It is, however, necessary to protect the top to prevent rain from entering the tube; but a cover tends more or less, according to its shape, to delay the current in the tube or shaft." This necessity of covering ventilating tubes or chimney tops to protect them from rain, does not exist in the case of soil pipes; these may only want protection against malicious introduction of stones or similar articles. A galvanized iron, copper or brass wire basket set into the mouth of the soil pipe will answer this purpose.

There is no doubt that open-mouthed pipes have a better upward ventilation than pipes covered with cowls, if the wind blows horizontally or nearly so. Wolpert in his "Treatise on Ventilation and Heating" states the average useful effect in per cents. of the velocity of the

wind, as derived from a number of experiments, to be:

68.6 per cent. for open-mouthed tubes,

51.9 per cent. for pipes capped with

Wolpert's new cowl,

35.8 per cent. for pipes capped with

Wolpert's old cowl,

for a horizontal direction of the wind. In other words, the upward suction in a tube without any cowl is in the average equivalent to over $\frac{2}{3}$ of the force of the wind, blowing over it in a horizontal direction. For pipes capped with Wolpert's new cowl it is only a little more than $\frac{1}{2}$ of the wind force, and for the old cowl it is $\frac{1}{3}$ of it. As an average for other directions of the wind Wolpert finds the upward draft in pipes covered with his new and old cowls to be 51.5 per cent. and 34.5 per cent., respectively, of the wind force.*

*The current of air in these experiments was created by a powerful fan, the velocity of the current varying from 8 to 31 meters per second (from 17.9 to 69.3 miles per hour), equivalent to high winds and hurricanes respectively. The diameters of the cowls tested varied from 0.787 to 3.937 inches. It is to be regretted that the author did not extend his experiments so as to include much smaller velocities of current. It is very likely that for the latter the percentage of useful effect of cowls would be much smaller.

The result of an elaborate series of about 100 experiments upon ventilating cowls, made on seven different days, at different times of the day, and under different conditions of wind and temperature, by Messrs. W. Eassie, Rogers Field and Douglas Galton, was as follows: "After comparing the cowls very carefully with each other, and all of them with a plain open pipe as the simplest, and in fact only available standard, the sub-committee find that none of the exhaust cowls cause a more rapid current of air than prevails in an open pipe under similar conditions, but without any cowl fitted on it. The only use of the cowls, therefore, appears to be to exclude rain from the ventilating pipes; and as this can be done equally, if not more efficiently, in other and similar ways, without diminishing the rapidity of the current in the open pipe, the sub-committee are unable to recommend the grant of the medal of the Sanitary Institute of Great Britain to any of the exhaust cowls submitted to them for trial."

FRESH AIR INLET.

The *second* requirement calls for a fresh air inlet or fresh air pipe. This is no less important than the extension of the soil pipes through the roof. In order to effect a constant movement and change of air in the pipes, two openings are required, an outlet and an inlet. The extension of the soil pipe through the roof provides only an escape for the foul air generated in the soil pipes and waste pipes through the decomposition of foul organic matter, clinging to the interior of pipes and lodging in traps under water closets and fixtures. But in order to oxidize and thus render harmless this matter undergoing putrefaction within the pipes, a constant introduction of fresh air from the outside atmosphere is necessary. As the soil pipe is warmer in winter time (being in the constantly heated house) than the fresh air pipe, located outside of it, an almost continuous upward current in the soil pipe results. In summer time this current is only seldom reversed; for

as a general rule, the top of soil pipe is heated by the sun more than the fresh air pipe near the ground.

There is a second and almost equally important reason for providing a fresh air inlet, wherever the third requirement, the trapping of the drain, has been complied with. If a water closet is used or a pail emptied into a slop sink, the water discharged into the soil pipe acts like a piston; although it is not likely to fill a 4-inch pipe, it certainly carries the air on its course downward with it by friction. Thus the descending water drives air before it and out through the fresh air pipe; if this had not been provided, it would very likely force the nearest traps under fixtures, and send a puff of sewer gas into the living rooms. This reversed action of the fresh air inlet does not occur sufficiently often to warrant the apprehension of any danger in the location of the inlet. Of course, it should not be too near under windows of living rooms or dormitories, nor should it be placed too near the front steps of a city house. A

little judgment should be exercised in locating the fresh air inlet. In cities, having between the house and the street a wide parking, it is best to build in this a small manhole, at the bottom of which the trap and opening for fresh air are located. The top of manhole should then be closed with a cover, having numerous openings so as to permit the outer air to enter the drain freely, and also to prevent as much as possible obstructions by snow or ice in winter time. For this reason it cannot be recommended to open the fresh air pipe into a gully in the sidewalk, or in the floor of an area. Equally objectionable is the location of the fresh air pipe in a coal slide. It seems best to carry the fresh air pipe some distance away from the house, and this is always practicable in the case of country houses, where the fresh air pipe should preferably be hidden from view by shrubbery.

If the main trap is located inside the foundation walls, the fresh air pipe should enter the drain just above the trap by a T or Y branch. Only in rare cases does

it become necessary to carry the fresh air pipe vertically upward through the roof. This plan would neither be very efficient, as the difference in temperature of inlet and outlet pipe would be small, nor very economical.

As regards size of the fresh air pipe, I would say that nothing short of the diameter of the iron drain would answer; as this is generally 4 inches in diameter, a 4-inch opening for fresh air pipe is required. This opening should be protected against obstructions by a wire basket similar to that used for the upper part of soil or waste pipes.

TRAP ON MAIN DRAIN.

Our *third* requirement calls for a trap on the main drain between the sewer, cesspool or flush tank, and the fresh air pipe. A *trap* is practically a suitable bend or dip in the drain, which retains a sufficient quantity of water to prevent the passage of sewer gas.

The opinions of experts as to the advisability of trapping the main drain are

divided, some considering the trap necessary, while others claim it should be omitted.

The objections urged against the use of traps are as follows:

1. They impede the ventilation of the public sewers.

2. They form an obstruction to the flow of the sewage in the house drain, and are, therefore, the cause of accumulations of foul matter in the drain, which by its decomposition will generate noxious gases; also

3. Foul matters will lodge in the trap.

While the first objection does not strictly belong to the subject of this paper I will say that it is accepted by most authorities that house drains and soil pipes should not be used as ventilators for the street sewers. In exceptional cases—such as, for instance, where an entirely new sewerage system is built, designed and constructed according to uniform plans, and where not only the construction of sewers, but also the house plumbing is under constant supervision of the

engineer and designer of the system*—the trap (and consequently the special fresh air pipe) may, perhaps, be left out. But I believe that a proper ventilation of sewers can be effectually carried out without ventilating through the houses.†

In regard to the second and third objections, I would say that obstructions do not frequently occur if the drain is carefully laid, with sufficient and continuous fall to insure a cleansing velocity of the flow. If such an inclination cannot be given to the drain, proper flushing appliances should be used, and these will by daily or more frequent washings, insure the removal of all matters liable to lodge in the trap. Another most necessary precaution to prevent accumulations in the trap, where the fall is very slight, may be found in the use of a proper grease trap, about which I shall speak hereafter.

* For instance, at Memphis, Tenn., and at Hamburg, Dantzic, Frankfort-on-Main, Berlin, Breslau, and other places in Germany.

† See Mr. Edward S. Philbrick's articles on "Ventilation of Sewers," in the *Sanitary Engineer*, Vol. I. See also *Sanitary Engineer*, Vol. V. Number 12, page 246.

No amount of care in laying the drain will prevent its obstruction through carelessly introduced articles; these will mostly lodge in the trap. A cleaning hole should therefore be provided with the trap, and is rarely omitted in good work, or else a Y branch, closed with a trap screw, should be inserted just a little above the trap.

In Vol. III. of the "Sanitary Engineer" will be found a discussion of the advisability of trapping the main drain. My own opinion, as stated in a communication to that journal, is as follows:

"If we could have *ideal* sewers, house drains and soil pipes, it might, perhaps, be possible to dispense with such a trap altogether. But since all sewers may have temporary stoppages from some cause, since house drains may settle or leak, and joints of soil pipes crack, thus allowing sewage matter to undergo putrefaction and enter the interior of houses, I would in all cases advise the use of a safeguard, consisting in a disconnecting trap and a *well ventilated soil pipe*. This

latter arrangement is a *conditio sine qua non*, and rather than have a trap *without* ventilation I would advise to have none at all. . . . I would always condemn as unsafe a system of house drainage in which the public sewers are ventilated through the houses. . . . The work of ventilating public sewers should, in my opinion, be done by the same public authorities who devise the sewer system, and not by the householders."

Leaving aside, however, the case of a house drain connecting with a public sewer, it seems quite evident that, in the case of a house discharging its sewage into a cesspool, an effective barrier should be imposed to the gases constantly generated in that receiver of all foulness from the household; and equally so in the case of a flush tank which temporarily holds a large amount of fæcal and other refuse matter, which sometimes undergoes decomposition.

The principle of disconnecting each house from the street sewer was first ad-

vocated in England, and its importance becomes most apparent in the case of an epidemic, as by the use of a trap each house will be isolated, while if all houses have an open connection with a sewer, this and the house drains may become the channels for spreading the disease from one house to another. It has been said by those not in favor of such disconnection, that the air of the house drain, the soil pipe and the branch wastes is much worse than that of most city sewers, and that consequently no harm could be done by allowing the sewer to breathe through the pipes in the house. Such statement may be true in regard to the sewers of some cities; in others, sewers, especially if built long ago, are extremely foul. But it seems to me that just where the air of drains and pipes is foul, it needs a strong dilution and purification by abundant *fresh air*, which an opening to the outside atmosphere can furnish, but never a direct connection with a sewer.

An open connection of the house drain with a sewer or cesspool is necessarily

based upon the condition that every joint in the house is perfectly tight, and every trap perfectly trustworthy. As plumbing is done in most houses these conditions are only seldom fulfilled. But even where in new work such a standard of design and workmanship has been reached, the work may not remain so forever. It is, therefore, advisable to use a trap on the main drain as a safeguard, but in addition to this to insist upon occasional inspections. These become a necessity in the case of large buildings, such as hotels, schools, large factories, jails and almshouses.

Incidentally, it should be mentioned that a trap on the drain performs a most useful office during repairs or alterations of the plumbing work in keeping from the interior of the building the gases from the sewer.

Much, of course, depends upon a proper kind of trap for such disconnection. The old so-called "cess pool trap" is, next to the pan closet and the D-trap, the worst device ever proposed in

connection with house drainage. As usually constructed it is of very large size, with square corners, and soon accumulates filth, becoming in a short time in reality a *cesspool*.

The common running trap, which is manufactured in earthenware as well as in iron is the simplest and at the same time the best of all forms. It should preferably have a vertical drop of a few inches from the drain to the water line in the trap in order to expel any solids that would tend to lodge in it. The running trap is often provided with a cleaning and inspection hole at the house side of the water seal, which serves as a fresh air inlet, when the trap is placed in a manhole outside of the house. In other instances a rain leader is inserted into the opening of the trap, which thus receives abundant flushing at each rain fall. The running trap is sometimes located on the line of the iron drain, just inside of the foundation wall, so as to be at all times easily accessible. A trap, in iron, with a cleaning hole and a cover is

then used. Care should be taken to close the cover perfectly air-tight.

In all cases the trap should be so located as not to be liable to freeze in cold climates or exposed localities.

In England various "disconnecting traps" have been used, such as Molesworth's trap, Prof. Reynolds' and Dr. Buchanan's disconnectors, Hellyer's Triple-Dip Trap, Pott's Edinburgh "air-chambered sewer trap," Stiff's "interceptor" sewer trap, Weaver's disconnecting trap, Mansergh's, Buchan's, Banner's, Stidder's, Bavin's traps, the "Eureka" sewer air trap, and many others. All of these may have certain merits, but nothing could be better nor cheaper than the common running trap with fresh air pipe used almost exclusively in American plumbing.

For those exceptional localities where undue pressure in the sewer, from wind blowing into the outlet of the sewer, or from sudden changes of temperature (when exhaust steam is allowed to enter a sewer), or from heavy accumulations of

surface waters gorging the sewer, or from the action of the tide in tide-locked sewers, frequently forces the seal of the trap, two running traps with a proper vent pipe between them have been recommended. I have myself, for some time, advocated such an arrangement, which, after further experience, I think complicated and unnecessary. It would require either a pipe extended through the roof, between the two traps, or else an open shaft (a manhole) between them, and besides this, in every case, a fresh-air pipe entering the drain above the upper trap.

TRAPPING OF FIXTURES.

The *fourth* essential, as stated above, calls for a suitable trap, placed as near as possible under every fixture.

As regards this point I cannot agree with the views of Prof. Osborne Reynolds of Owens College, Manchester. In his otherwise excellent little book, "Sewer Gas and how to keep it out of Houses," after explaining the necessity of a dis-

connecting trap on the main drain, and giving particulars about its construction, he continues: "There will then be no need to have traps within the house."

Traps under fixtures become a necessity, as much of the so-called "sewer gas" is actually generated in the drain and soil pipes of the house. Even the waste from a wash bowl becomes coated in time with a soapy slime, emitting bad odors. The trap on the main drain would offer no protection against the foul gases derived from organic matter decomposing within the pipes. We thus see that, while some advocate the trap on main drain, but no traps under fixtures, others leave out the main trap, but trap the outlets of all fixtures. In my opinion, both the trap on main drain and those under fixtures are necessary.

Traps should be located as close as possible to fixtures, in order to reduce the length of waste pipe on the house side of the trap, which is liable to become foul with long use. Probably the best material for traps is lead, as this permits of

making a good joint with the lead waste pipes. As Mr. Hellyer has truly pointed out, the junction of the trap with the waste pipe is of far more importance than its junction with the fitting, because the former is on the sewer side of the trap, and, unless properly made, would afford a passage for gases from the waste pipe system into the rooms.

Whatever kind of trap may be used under fittings (and there is an endless number of such patented devices), it is of the greatest importance that the trap should be *self-cleansing*; for this reason traps with square corners or large spaces, liable to accumulate dirty matter, are objectionable. Much depends on a proper size of traps for waste pipes: the smaller the trap the better will it be washed clean. As a good rule I would recommend to choose a trap a quarter or half an inch smaller than the diameter of the waste pipe, to which it is attached. The flushing stream is thus concentrated, and its scouring power increased within the trap, while on the other hand

a trap an inch larger than the waste pipe is sure to fill up in time with sediment.

The following will serve as a guide :

Traps under water closets with 4 in. soil pipe should be $3\frac{1}{4}$ in. to 4 in. diameter.

Traps under wash basins with $1\frac{1}{4}$ in. to $1\frac{1}{2}$ in. waste pipe should be 1 in. to $1\frac{1}{4}$ in. diameter.

Traps under bath and foot tubs with $1\frac{1}{2}$ in. waste pipe should be $1\frac{1}{4}$ in. diameter.

Traps under laundry tubs with $1\frac{1}{2}$ in. to 2 in. waste pipe should be $1\frac{1}{2}$ in. to $1\frac{3}{4}$ in. diameter.

Traps under sinks with $1\frac{1}{2}$ in. to 2 in. waste pipe should be $1\frac{1}{4}$ in. to $1\frac{1}{2}$ in. diameter.

Traps under slop sinks with 2 in. to 3 in. waste pipes should be $1\frac{1}{2}$ in. to 2 in. diameter.

As regards the proper dip of traps I would say that traps under those fittings which receive solids (water closets) should not have a greater dip than $1\frac{1}{2}$ to 2 inches, because otherwise the solids are not readily removed, and lodge in the trap. For traps of minor wastes a larger dip or "water seal" is advantageous, as affording a protection against loss of seal through evaporation, siphonage or back pressure.

Traps may be classified according to

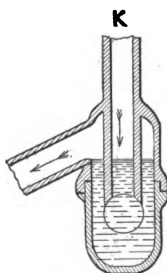
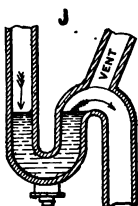
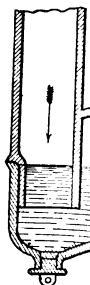
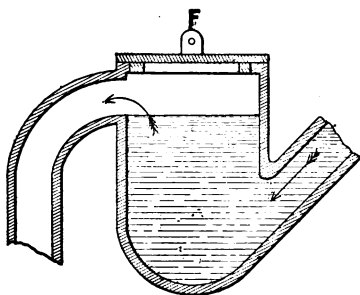
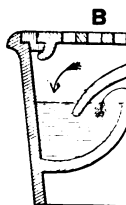
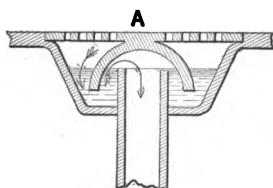
the means used for the exclusion of gases into :

1. *Water-seal traps.*
2. *Mechanical traps.*

The characteristic of all water-seal traps is that they have in their lowest part a bulk of water divided by a dip in the pipe, so as to stand on the house side as well as on the sewer side one or several inches higher than the lowest point of the dip, thus making a seal which, under ordinary circumstances, prevents the passage of gases.

The traps of the second class have, in addition to the water-seal, a mechanical contrivance such as floats, balls, valves, flaps, &c., to exclude sewer gas.

Of water-seal traps I mention the bell trap, Antill's trap, the old fashioned D-trap, the bottle or round trap, Adees's trap, the Climax trap, the common S-trap, P-trap and three quarter S-trap. There is an endless variety of mechanical traps, amongst which I mention Bower's trap, Cudell's trap, Garland's trap, Buchan's



trap, Waring's check valve, Nicholson's mercury seal trap, and others (see Fig. 2.)

The bell trap A is objectionable on account of insufficient water seal and improper shape. It is frequently found at the outlet of sinks and yard gullies, and being in its upper part a movable strainer, it is often lifted by servants or thoughtless persons, and the gases from the drain pipe thus enter the house freely.

Antill's trap B avoids this defect, having a *fixed* strainer, but is objectionable on account of shape and small water-seal.

The D-trap C and the bottle trap D constitute small cesspools; they violate the principle that a trap ought to be self-cleansing. The D-trap accumulates dirt and grease in the upper corner, which receives no scouring from the water passing through the trap; and the bottle trap very often chokes up as shown at E. A round trap of improved shape is shown at F, which may keep cleaner on account of its round bottom.

Adee's trap G is little better in this respect, though it has this to recommend it that it is not so easily siphoned, having a large air space above the water, and a large body of water in the trap. This is also true of the round trap, when new and clean; when choked with grease as shown at E, it is as much liable to siphonage as the S-trap.

The Climax trap, H, has a large dip and a round cup at its bottom, which is removable for cleaning purposes. Its resistance to siphonage is not greater than that of any of the other traps, or that of the common S-trap with same depth of water-seal.

The P-trap I, and S-trap J, are shaped so as to be perfectly self-cleansing when adapted in size to their waste pipes. They are of uniform diameter throughout, have no nooks or corners to accumulate dirt. The old hand-made S-traps with seams have been superseded by lead traps cast in a mould such as the Du Bois traps. As regards cleanliness these traps are undoubtedly superior to

all other traps of which I have knowledge. They cannot, however, be relied upon to exclude sewer gas, as their water-seal is frequently destroyed either by siphonage or by evaporation. They are shown in Fig. 2, with a vent pipe attached at the highest bend of the trap on the sewer side of the seal. The object of this vent pipe is to prevent siphonage, as will be explained hereafter.

Bower's trap is shown at K. This trap has a water-chamber into which the pipe from fitting enters at the center, and an outlet pipe on one side. The mouth of the inlet pipe is sealed by the water in the chamber, but in addition to this a floating ball of india-rubber in the water chamber is held tightly against the mouth of the inlet pipe, forming a seal, which, however, depends on the quantity of water in the chamber. The water, in passing through this trap, removes the ball from its seat and rotates the same, thus keeping it clean and free from matters adhering to it. An additional advantage of this trap lies in the ball, which,

being compressible, allows the water in the chamber to freeze without danger of the bursting of the cup. Unless the soil pipe is extended full size through the roof this trap may have its water lowered by siphonage so much that the ball will drop from the mouth of the inlet pipe, but with proper ventilation of soil and waste pipes it forms an efficient trap for wash bowls, tubs and sinks, although it is not as self-cleansing as the common S-trap.

Waring's check-valve is shown at O. This valve forms a seal by its weight, and the seal is dependent upon the accuracy of the turned seat. Hair and particles of other matters may adhere to it and prevent a tight shutting of the valve.

Cudell's trap L and Buchan's trap M are constructed much upon the same principle, but have a heavy metallic ball instead of a conical-shaped valve. This ball may keep cleaner by being revolved, but in this case, as above, the tightness of the

seal will depend upon the accuracy of turning the seat.

Nicholson's mercury-seal trap N has an inverted porcelain cup inside of its cylinder, the edge of which rests on mercury, forming a tight seal. The cup is lifted, at each discharge, by the force of the water entering at bottom of cylinder; after all water has passed from the basin the cup falls back in its place. This trap is generally made of earthenware with brass couplings ; it is therefore a more expensive trap, but the mercury seal very efficiently prevents the entrance of sewer air, even if the water in the cylinder should be removed by siphonage or evaporation.

VENTING OF TRAPS.

The *fifth* requirement asks for a proper vent pipe for such traps under fixtures as are liable to be siphoned. This siphonage constitutes in many cases a danger, but especially so with S-traps. Traps may be siphoned under the following conditions :

1. Traps with an easy bend, on a rather steep line of waste pipe, and with small depth of seal, are liable to empty themselves by the momentum of the water rushing from the fitting through them. The air in the upper bend of the trap is expelled and replaced by water, which causes the trap to act as a siphon. When the fitting has discharged all its water, and air breaks the siphon, the water in its inner limb will mostly drop back into the trap, but in case of a small dip it would be insufficient to seal the trap. Unless a slow after-flush takes place the trap remains unsealed.

2. Traps under fixtures may be siphoned by a flow of water coming from another fitting on the same branch waste pipe.

3. Traps may be siphoned by a discharge—from a water closet, a tub, or from a pail of water from a slop sink—into the main soil pipe, to which the branch waste of the trap is connected.

To guard against the *first* danger the dip or water seal of the trap should be

as great as possible; but, even then a special vent pipe will often be necessary, attached to the highest part of the bend in the trap on the sewer side of the water-seal, or else a mechanical trap should be used.

To guard against the *second* danger the trap of each fixture should be vented; wherever possible, each fixture should discharge independently into the soil pipe, thus reducing the danger from siphonage to cases 1 and 3.

The *third* danger from siphonage by a discharge into the main soil pipe, either above or below the point where the waste from the trap enters it, will in some cases be sufficiently prevented by the complete and thorough ventilation of the soil pipe. In many cases, however, the venting of the trap becomes necessary.

Where a number of water closets discharge into the same inclined branch of a soil pipe the air-vent to the water closet trap becomes necessary, especially so with water closets, discharging quickly a large body of water, such as the various pat-

terns of the plunger closets (Zane, Demarest, Jennings) and some of the "wash-out" closets.

Where slop hoppers are trapped by an S-trap, this must be properly guarded against siphonage, as the trap is very likely to lose its seal from the momentum of the water rushing through it each time a pail of slops is quickly emptied into the sink.

The material most suitable for air pipes is lead, as such pipes are easily joined to lead traps. Sometimes wrought-iron tubing is used, and, since the vent pipe is not so much intended for carrying off foul gases [which office is performed by the vertical extension of all waste pipes through the roof] as to afford a passage to air in order to break the suction, they may be safely used. Care should be taken to lay these pipes with a slight inclination, in order to prevent accumulation of water from condensation in the pipes. Vent pipes for fixtures on different floors may be joined, if convenient, and may enter the soil pipe above the highest fixture. But

it is preferable to run them to a main vent pipe of lead, or better, cast iron, which goes through the roof independently. Where this passes through the roof it must be enlarged to 4 inches diameter, as it might otherwise be obstructed by ice in winter time. It should not be covered at the top with any kind of ventilator. The size of the vent pipe should never be less than that of the trap, except for water closet traps, where it should be 2 inches in diameter, but in the case of two or more water closets it should be 3 inches and sometimes even larger from the point where the various vent pipes join.

It is often not only costly but also inconvenient to run vent pipes to the roof. There is also some danger that the vent pipes for traps under tubs, sinks and bowls may stop up with soapsuds or grease, in which case they would cease to act properly. The continuous current of air in the vent pipe, in passing over the water in the trap, will tend to increase its evaporation. Finally it becomes nec-

essary in the case of high buildings, largely to increase the diameter of vent pipe in order to make up for the loss through friction necessarily occurring with long air pipes. Therefore, while I consider vent pipes for traps a necessary evil in many cases, I am inclined, in other cases, to prefer a good mechanical trap, which cannot be siphoned, provided the soil and waste pipe system has ample ventilation. Such mechanical trap may be used under sinks, tubs and bowls; but for water closets and slop hoppers (if without a strainer) the simple lead water seal trap with vent attached is the only safe device.

EVAPORATION OF WATER IN TRAPS.

Nothing short of continuous use of the fixtures will prevent evaporation of the water in traps. A large dip is recommended for traps on waste pipes to guard against a rapid loss of the seal. When a house will be left unoccupied for a long time, but especially during the hot summer months special precautions should

be taken to prevent sewer gas from entering the rooms and saturating carpets, wall-paper and furniture. Replacing the water in traps with oil or glycerine may be recommended, or else the use of common rock salt which attracts sufficient moisture from the atmosphere to make up for the loss by evaporation.

ABSORPTION OF GASES BY THE WATER IN TRAPS.

It is well known that water has the property of absorbing gases, and it was believed that the water in traps would readily absorb sewer air from the soil pipe and give it off at the house side of the trap by evaporation. It has also been asserted that microscopic organisms (germs of disease) floating in gases of decay would pass through the dip of the water-seal and enter the house through the fixtures, and that consequently the water-seal of traps offered no security against the invasion of sewer gas. Dr. Fergus, of Glasgow, Scotland, was the first to call attention to this matter, and made an extensive series of experiments

in 1873-74, which led him to condemn as unsafe the system of water carriage in general, and the trapping of fixtures. The views of sanitarians, based upon Dr. Fergus' experiments, have been much modified by recent experiments of Dr. Carmichael, of Glasgow, by researches of Dr. Frankland in London, Wernich and Naegeli in Germany, Prof. Rafael Pumpelly and Prof. Smyth in Newport, R. I.; and others.

Dr. Fergus' experiments were made with gases in a concentrated condition, and as such are quite as reliable as the more recent experiments. But the latter more closely resemble actual cases, being made by experimenting directly with soil pipe gases. Referring to what has been said about sewer gas, it will be seen that ammonia, sulphuretted hydrogen and other gases of decay are present in drains and soil pipes only in minute quantities. Dr. Carmichael found that the amount of these gases passing through a water-seal trap was so extremely small that no danger could be apprehended. With a thor-

oughly ventilated system of soil and waste pipes this peril may be taken as insignificant.

Another set of experiments by Dr. Carmichael, made to determine the passage of germs through water, seems to indicate that germs, even if contained in the water of traps, are not liberated from it, as was hitherto supposed, unless the water is violently agitated. Frankland in England, Naegeli in Germany and Prof. Pumphelly in Newport, R. I., arrived at the same conclusion, after careful investigations and experiments.

Dr. Carmichael sums up his conclusions by saying: "Water traps are, therefore, for the purpose for which they are employed, that is, for the exclusion from houses of injurious substances contained in the soil pipe, perfectly trustworthy. They exclude the soil pipe atmosphere to such an extent that what escapes through the water is so little in amount, and so purified by filtration, as to be perfectly harmless; and they exclude entirely all germs and particles,

including, without doubt, the specific germs or contagia of disease."

Further scientific researches will undoubtedly throw more light on this yet little investigated subject.

TRAPS FORCED BY BACK PRESSURE.

It has already been explained how traps under fixtures may be forced by back pressure. This cannot, however, occur with traps under fixtures, if all soil and waste pipes are properly extended through the roof, and provided with a fresh air opening at their foot.

BRANCH WASTES FROM FIXTURES.

Fixtures are connected to the soil and waste pipe system by branch wastes carried under the floors. The material used almost exclusively for such branch wastes is lead, and the sizes adapted to different fixtures have already been stated. The connection is very simple in the case of a single fixture, such as a kitchen sink, or a lavatory. The problem becomes more intricate in the case of a set of

fixtures, such as are generally located in a bath or dressing room. A bath room of the better class of city houses contains a water closet, a bath tub, and a lavatory, sometimes also a hip-bath or bidet. It is desirable that each of these fixtures should have a separate connection to the soil pipe. Such is seldom possible, except when the soil pipe is located in a special shaft, or where it is possible to conceal the pipe and Y branches by a "false ceiling," as the height of timbers does not generally allow of the placing of more than one Y branch.

A very common, but most defective manner of overcoming the difficulty is by emptying the wastes of bath tub and bowl into the water closet trap below its water line, supposing the water closet to be of such type as requires a lead trap below the floor. As the waste pipes have only a slight fall to the trap, the water of the latter, which frequently holds excremental matter, will stand for a long distance back in the waste pipe and keep it continually foul; the free flow from

the bath and bowl is much retarded, the waste being air-bound between the water closet trap and the traps of bowl and bath. Matters are even worse, when the water closet trap is meant to serve also as trap for the bowl and bath, these having no traps placed under them. The foul water standing back in the waste pipes will then readily evaporate into the dressing room, and fill it with noxious odors. Moreover, it frequently happens that this trap becomes displaced by tipping over, or that the waste pipe attached to the trap sags, so as to render the water-seal, which is rarely over an inch in depth, ineffective. It will be readily understood how, under such circumstances, the foul gases of the soil pipe—especially if this be unventilated, as is so often found in examining old houses—gain an easy access into our rooms. Should the main drain have an untrapped connection to a sewer or cesspool, the gases from these would ascend and permeate the whole building. Such instances of faulty work are by no means rare, and are causes

of much preventible headache and sickness.

To run such wastes into the water closet trap above its water line is equally wrong.

Where the water closet is some distance away from the soil pipe, it is possible to insert between its trap and the junction with the soil pipe, on the horizontal part of the soil pipe, two 4" \times 2" Y branches, or else one double Y branch for bath and bowl wastes. Where the water closet is quite near the soil pipe, and the connecting pipe between them is of lead, the wastes from bowl and bath may join the latter beyond the trap. Wherever there is room enough, a 4" \times 2" double Y branch may be inserted vertically below the water closet branch on the soil pipe, or else one 4" \times 2" Y for bowl above the water closet branch, and a 4" \times 2" Y below it for the bath waste. It seems desirable that the iron works should manufacture a combined Y branch, having a 4-inch opening for the water closet waste, and one or two 1½ to 2 inch openings for the smaller wastes.

Long lengths of waste pipes under floors are objectionable; to avoid them it is sometimes better to provide a special stack of $1\frac{1}{2}$ to 2 inch vertical iron waste pipe near lavatories or baths, where these are remote from the main soil pipe.

It is customary to provide bath tubs, wash bowls, and pantry sinks with an overflow pipe, in order to prevent flooding of floors, if the outlet of any of these fixtures should be closed by a plug, and a faucet carelessly left running. These overflow pipes should enter the waste between the fixture and its trap, or else they should enter the trap below the water line, so that the trap serves for both waste and overflow. Overflow pipes do not receive a thorough flushing, and are liable to become foul with soapsuds, emitting unpleasant odors. For baths, fortunately, the overflow pipe can be safely dispensed with by using the standing overflow, for bowls those with "patent overflow," *i.e.*, a concealed channel in the earthenware bowl, have the length of overflow reduced to a minimum.

A set of laundry trays is generally trapped by only one trap, thus leaving a long length of waste pipe in connection with the air of the room. I believe, however, that such wastes, properly restricted in size, and laid with sufficient inclination, can be kept well flushed and clean, and therefore unobjectionable.

In the case of a set of water closets or urinals I consider it imperative to have a separate trap under each fixture.

It is of the utmost importance that the connection between water closet and soil pipe should be *absolutely tight*. The different types of water closets are provided at their outlets either with a lead trap under the floor, or else they have a trap of iron or earthenware, as the case may be, above the floor, or they are so-called "trapless" closets, in which case the only water-seal against gases is formed by the water held in the bowl (either by a valve, pan or plunger, or by a special shape of the bowl). For water closets having a lead trap under the floor a brass ferrule is connected by a wiped

joint to the end of the trap, and the ferule is inserted into the hub of the iron soil pipe, and caulked tightly. The house end of the lead trap is flanged out, and the earthenware or iron horn of closet inserted into it, resting with its horizontal flange upon a ring of soft india-rubber, or of oakum, saturated with red lead. Wood screws, drawn through the horizontal flange into the floor, tighten the connection.

In the case of trapless closets and such with trap above the floor, the outlet is generally connected by a lead thimble to the soil pipe in the same manner as just described for lead traps.

Such a connection is in neither case a perfect one. But in the case of closets with trap under the floor, this connection is on the house side of the trap, and the danger from leakage of sewer gas from the soil pipe is prevented by the water seal. With trapless closets (such as some pan closets, valve closets and plunger closets), with closets having trap above floor (short hopper, some

plunger closets), and finally with all "washout" closets such a connection is dangerous, and a better joint than is used at present should be devised, such as, for instance, a connection by means of a brass ferrule between water closet outlet and iron soil pipe.

SAFE-WASTES.

In order to prevent the flooding of floors and ceilings, fixtures, such as wash bowls, bath tubs, water closets, etc., are mostly lined with a safe of sheet lead, provided with a waste pipe. In bad plumbing work these "drip pipes" are either joined into the nearest soil or waste pipe—often even without a trap—or else, in the case of water closet safes, are made to run into the water closet trap. Such drip pipes should not be connected at all to the drainage system. They should run vertically downward to the cellar, and open either over a sink, or terminate at the cellar ceiling. Should it be feared that the drip pipes might become the channels for leading the cel-

lar air into the upper rooms, their mouths should be closed with paper, glued over them, or the pipes should have an upward bend, closed by a ball, which is prevented from dropping by wire bands.

RAIN LEADERS.

Rain-water pipes may be of galvanized wrought-iron, or of tin; when laid inside of a house they should be of cast iron and their joints treated in all respects as those of soil pipes. Before joining the house drain they should be trapped, if such junction is made beyond the main running trap of the drain, and the trap of the leaders should be sufficiently deep in the ground to prevent the water from freezing. If rain leaders join the drain inside of the house they should not have a special trap, unless their top opens near dormitory windows. Sometimes a leader delivers into the main trap of the drain, and thus helps to cleanse the trap.

Rain leaders should never be used as soil pipes nor should they be solely depended upon to ventilate the drain; and,

on the other hand, soil pipes should never be used to carry rain water from th roof.

In making a sanitary examination of the Executive Mansion at Washington, under direction of Col. Geo. E. Waring, Jr., the writer had occasion to see an instance of the violation of this rule. The main soil pipe in the building was a 10-inch (1) cast iron pipe, which served the double purpose of receiving the discharge from three water closets, a urinal, a slop sink and some wash bowls and bath tubs, and also all the rain water from the large roof. At each rain-fall this large pipe received ample flushing, but in times of prolonged droughts its inner walls became thoroughly slimed and foul with excremental and other matter. In times of violent rain storms the water rushing down the 10-inch pipe and passing the branch wastes, very likely siphoned all water out of the traps, thus leaving the house unprotected against the foul gases of the soil pipe.

CISTERN OVERFLOW PIPES.

Both under-ground cisterns and cisterns in the attic of a house should be provided with an overflow. The usual custom has been to connect this overflow pipe to the drain, or, if inside a house, to the soil pipe. In consequence of this most pernicious practice the water was contaminated, and since water is known to be a carrier of disease germs not less so than the air, sickness and deaths were traced to this faulty arrangement.

No overflow from a cistern for cooking, washing or drinking water should be connected to any part of the drainage system under any circumstances. Even if properly trapped the danger is not removed, as the water in this trap evaporates, and as an overflow seldom occurs, no water refills the trap, and drain air passes freely into the tank. This overflow should be made to run into the gutter of the roof, wherever this is practicable. In cold climates or in exposed places its outlet should be protected by

a flap-valve. If, for some reason, the above course cannot be followed, the overflow should discharge over an open sink in the basement or cellar. If the cistern is located outside of the house, the overflow should be carried to some low point, where it should have an open outlet. Blow-offs for water-tanks should be treated similarly to the overflow-pipe.

REFRIGERATOR WASTES.

It is not safe to have a direct connection between a refrigerator waste and drain or soil pipes, for reasons given above for overflows of cisterns. Small refrigerators may waste into a pail to be removed and emptied periodically. Wastes from large refrigerators should empty over an open cup with a waste at its bottom, provided with a reliable mechanical trap and connected to the nearest soil pipe or drain.

DRAINAGE OF CELLARS.

It remains to discuss the proper method of removal of excessive moisture

from the soil under and around a dwelling. Unless this is properly attended to, cellars of houses will be continually damp, the brick or stone walls will readily absorb the moisture by capillary attraction and an excess of watery vapor will fill the house. The well known researches of Dr. Bowditch of Massachusetts, and of Dr. Buchanan in England, have clearly established the relation of excessive soil moisture to certain diseases, notably *consumption*, bronchitis, pneumonia and other diseases of the lungs.

Dr. Parkes, in his admirable "Manual of Practical Hygiene" speaks about diseases connected with moisture and ground-water as follows: "Dampness of soil may presumably affect health in two ways—(1) by the effect of the water, *per se*, causing a cold soil, a misty air, and a tendency in persons living on such a soil to catarrh and rheumatism; and (2) by aiding the evolution of organic emanations. The decomposition which goes on in the soil is owing to four factors, viz.: presence of decomposable organic

matters (animal or vegetable), heat, air and moisture. These emanations are at present known only by their effects; they may be mere chemical agencies, but more probably they are low forms of life which grow and propagate in these conditions. At any rate, moisture appears to be an essential element in their production. The ground-water is presumed to affect health by rendering the soil above it moist, either by evaporation or capillary attraction, or by alternate wettings and dryings. A moist soil is cold, and is generally believed to predispose to rheumatism, catarrh and neuralgia. It is a matter of general experience that most persons feel healthier on a dry soil."

In order to keep the level of the sub-soil water below a certain depth artificial channels should be provided, laid at that depth and sloping towards some proper outlet which will remove all surplus water. These channels, which carry off only clean water, are also called *drains* (this being the original meaning of the word).

Under the foundation walls of the house trenches dug for this purpose should be filled with loose or broken stones. Drains (common tiles) should be placed two or three feet below and under the cellar floor, with open joints, care being taken to prevent any intrusion of earth at the joints, by wrapping tarred paper or strips of cotton around them. The drain can then be covered up and buried. The size of the tile drains will depend on the character of the soil. As a general rule $1\frac{1}{2}$ -inch tiles are quite sufficient, except in the case of a spring in the cellar, when it may be necessary to use pipes of 2 inches and sometimes even larger sizes.

The only difficulty, from a sanitary point of view, consists in finding a proper outlet. If the house is a country residence with ample ground around it, and especially if the land is not level, but slopes to some distant valley or creek, it is very easy to continue the main cellar drain with a sufficient pitch to some gut-

ter or open ditch, into which it may discharge.

The case becomes difficult with city houses, on narrow lots, with no other outlet available but the sewer under the street. A direct connection between the cellar drain and the sewer is forbidden for well-known reasons, and even the interposition of a water-seal trap may not be regarded as a sufficient safeguard, for during periods of droughts the water evaporates, allowing the gases from the sewer to pollute the ground under the house.

The drain should run into a mason's trap, with *deep* water-seal, and filled with coarse sand or fine gravel, and before joining the sewer the drain should be trapped by a running trap, into which, if practicable, a leader should discharge. Another arrangement is to trap the cellar drain, and to provide an outlet for gases which may force the trap, by a vertical pipe, on the house side of the trap, and opening on the surface of the ground. This is sometimes done when the sewer

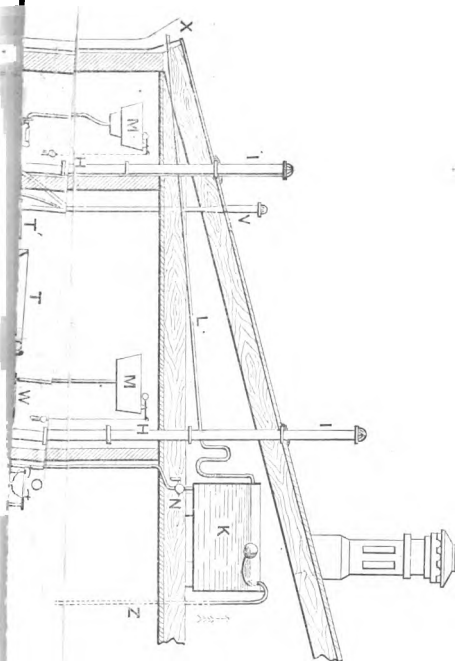
is in an alley at the rear of the house, and an open yard gully may be connected to the vertical vent pipe to supply the running trap with water.

It is equally important to have a dry, impervious floor in the cellar, which can be secured by first laying a base of concrete, upon which a layer of about $\frac{1}{4}$ inch of asphaltum should be placed. This makes the floor practically impervious. It should then be properly finished with a layer of best Portland cement.

DAMPNESS OF WALLS.

In order to prevent dampness of walls, that part of the wall below the level of the ground should be constructed with particular care. Nothing will better prevent dampness in walls than a "damp course" of some impervious material. Asphaltum is probably best for this purpose, though layers of slate in concrete or damp proof tiles are very efficient. If at all practicable there should be a dry area all around the foundation walls in order to prevent any dampness in the walls originating

Fig. 3.





from the earth surrounding it at the sides. If such an area cannot be provided a *double* wall with an air-space between inner and outer walls should be used.

SYSTEM OF HOUSE DRAINAGE.

Fig. 3 represents a section through a dwelling house, illustrating the essential elements of a system of house drainage.

A is the gravel trap, into which the subsoil drain B discharges, and which serves to prevent the gases from the sewer from entering the drain tiles and permeating the cellar. The drain B for cellar drainage should be of common $1\frac{1}{4}$ -2-inch tile drains, laid with open joints, around which tarred paper or cotton rags may be wrapped to prevent any stoppage of the tiles from dirt falling in at the joints.

C is the house drain, which should consist of 4-inch vitrified pipe with well cemented joints to within 10 feet from the cellar wall. D is the running trap on the main drain to disconnect the house from

the sewer. Into it the rain leader X discharges. E is a Y branch, closed with a brass trap screw, for cleaning purposes. F is a fresh air pipe, 4 inches in diameter, entering the house drain above the trap, and carried some distance away from the house, its mouth being hidden from view by shrubbery, and covered with a wire basket for protection against obstructions.

G is the 4-inch house drain, of heavy iron pipe, with well caulked lead joints, carried with sufficient fall along the cellar wall to the furthest point, where it receives either a soil pipe or a rain leader.

H H are the 4-inch iron soil pipes, which join the iron drain in cellar by Y branches and eighth bends. They are extended full size through the roof, and their outlets I I are protected by a strong wire basket.

J is a small refrigerator which wastes into a movable pail. K is the large tank in attic, which is supplied through a ball-cock from street pressure. Its overflow

pipe L is shown trapped by an S-trap with deep seal, and emptying into the gutter of the roof. The blow-off N from tank runs down vertically and delivers over the kitchen sink.

M M are small cisterns for flushing the water closets and slop hopper *only*.

O O are earthenware wash bowls with $1\frac{1}{4}$ -inch waste pipes and overflow pipes of lead, trapped by Cudell's or Bower's traps, and delivering into $4'' \times 2''$ Y branches of soil pipes.

P is a pantry sink, of heavy tinned and planished copper, with overflow and $1\frac{1}{4}''$ waste pipe of lead trapped by a Bower's trap and entering a Y branch of soil pipe.

Q are cement stone or ceramic wash tubs, with $1\frac{1}{2}''$ waste pipe, and trapped by a Bower's trap.

R is an all-earthenware flushing-rim slop hopper, trapped by a vented S-trap, and flushed from a special cistern.

S is the kitchen sink, of galvanized or enamelled iron, or of earthenware, trapped by an $1\frac{1}{4}''$ Bower's trap with $1\frac{1}{2}''$ lead waste pipe.

T is a bath tub, of enamelled iron, or heavy planished copper or of porcelain. It is provided with a standing waste, and trapped by an 1½" Cudell running trap.

T' is a small hip bath, of copper, provided with overflow and 1½" waste pipe, trapped by a vented S-trap.

V is a 2-inch air pipe to prevent the siphonage of traps. It is extended through roof, and enlarged to a 4-inch outlet, which should be left without any other covering than a wire basket. Into this air pipe enter the vent pipes from S-traps under slop hopper, water closet and hip bath.

W W W are water closets, the types shown being the long and short hopper and the washout closets. Each of these is provided with a special flushing cistern **M M M**.

XX is a rain leader delivering the water into the running trap of the house drain.

Y is the blow-off from the boiler, which wastes into a Y branch of the iron drain in cellar.

The system described and illustrated differs from the methods of house drainage as practiced in England in one essential point. There, it is the rule to keep soil pipes separate from waste pipes, to deliver to the former, in the words of Prof. Fleming Jenkin, "such foul matters as would certainly be tainted when contagious disease occurs in the house," in other words, the waste water from water closets, urinals, slop sinks and probably laundry tubs; a second system "receives all liquids, which may be called dirty, but not foul—the water from baths, kitchen sinks, and wash hand basins." It is, moreover, the rule in England to locate the soil pipe outside of the house walls, and to deliver the waste pipes over an open gully in the yard, from whence the wastes run into the house drain. Both arrangements are entirely impracticable in this country on account of the severity of the climate, and the separation of the two systems by discriminating between foul and dirty waste water leads to unnecessary complications. With well joint-

ed, thoroughly ventilated soil pipes of iron, it seems quite permissible in American plumbing to run into them the wastes from any fixture in the house, if it be near the soil pipe, and where vertical stacks of waste pipes are run for bath tubs and wash basins, these waste pipes, if properly jointed, may with perfect safety deliver into the iron cellar drain, which receives the soil pipes of the house.

If all the given rules are carefully observed, the system of drainage of a dwelling will be as perfectly as possible in accordance with the present knowledge of sanitary science. Time and experience may find out hitherto unknown faults, but will also, it is believed, teach the proper remedy. *With pipes of proper material, properly joined, properly laid, and properly and sufficiently often flushed with air and water, the object of a system of house drainage seems to be attained, viz., the instant removal from the house of all liquid and semi-liquid waste matter, and the perfect oxidation and con-*

stant dilution of the air contained in the pipes.

Says Mr. J. C. Bayles: "The conclusion I have reached is that when sewer gas finds its way into a house through the soil and waste pipes, the fault lies somewhere between the architect, the builder and the plumber. In any case, it is without excuse. I know that houses can be drained into sewers—without bringing sewer gas into them. The existence of foul sewers is in itself a perpetual danger to the public health, but there is no reason why we should bring that danger into our houses by providing channels through which the poisonous air of the sewer can find a means of ingress. I know of houses into which no sewer gas ever comes—unless, possibly, through the windows, borne in with the air of the street—and I have no hesitation in saying that, when the tenants of houses demand immunity from the dangers of unhealthful conditions, architects and builders will find a means of correcting the evils now complained of as practically

irremediable. Sanitary reform in cities only waits until those to be benefited by it shall demand it."

RECORD AND PLAN OF DRAINAGE AND PLUMB-
ING INSPECTION.

It cannot be too strongly recommended to every householder to keep for future reference, for cases of inspection or repairs and alterations, a complete plan of all the drain, soil and waste pipes in and outside of the house; a record of the depth of the drain, of the sizes and material of pipes, of the location of junctions, traps, fresh air pipes, access pipes or cleaning Y's, of all fixtures on every floor, etc.

Frequent inspections of the plumbing of buildings are by no means superfluous. They are very important in the case of public buildings, schools, hospitals, asylums, jails, hotels, but especially so, for such buildings as are occupied only a part of the year (summer residences, seaside hotels, mountain resorts, etc.). In some cities "sanitary associations" have been organized, such as at Newport,

R. I., Lynn, Mass., Brooklyn, N. Y., and other places. The members of these associations can avail themselves of the services of an inspector of plumbing employed by the association, in order to assure themselves by frequent inspections of the sanitary condition of the plumbing in the house, of its outside drainage and water supply, its ventilation, etc.

In the case of new buildings the architect's plans should show the exact location of the proposed plumbing work in the house. The work should be done according to written specifications, carefully drawn up by the architect or a sanitary engineer, under whose immediate direction the plumber should work. It is a mistake — but, alas! how often is it made — to give the plumbing work of a new building out by contract. The slight amount saved in first expense is almost always followed by an increased outlay for repairing and altering defects, which appear only after the house is occupied. A prudent house owner will prefer to have his plumbing done by day labor, by honest,

conscientious plumbers—and these are by no means rare, as the universal cry against them would seem to indicate—who care more about their reputation than about a few dollars earned through dishonest and reckless work.

PLUMBING REGULATIONS.

The cities of New York, Brooklyn and Washington lately have set an example worthy of imitation in other cities. The health authorities have issued excellent regulations for plumbing of buildings, and require the plans for plumbing to be submitted to them for approval and for filing. The plumbing, before being covered up, is examined by intelligent inspectors of the Board of Health. There may be at first some bad feeling about such a measure, but the good plumber will soon understand that the law passed is to his advantage; it will protect him against the “botchers” in the trade, and will help to re-establish his of late much abused good name.

These plumbing regulations will cer-

tainly tend to lessen the frequent complaint about bad plumbing in houses, and the consequent entrance of sewer gas. They will contribute much towards the lowering of a high death rate, and similar regulations may be adopted with advantage in all large cities.

PLUMBING FIXTURES.

The various plumbing fixtures which receive and deliver to the drain the foul wastes of the household, will be reviewed here only from a sanitary point of view. For more detailed technical descriptions of plumbing appliances I refer to the interesting series of articles on "Modern Plumbing," by T. M. Clark, Esq., in the *American Architect* for 1878, and to numerous papers on "Plumbing Practice" in the *Sanitary Engineer*.

Plumbing fixtures should be concentrated in a house as much as possible, so as to render necessary only few vertical stacks of soil and waste pipes, and to avoid long horizontal runs of pipes, which are objectionable inside floors,

first, because they necessitate the cutting of beams ; second, because they prevent the running of waste pipes with proper fall. Much may be effected in planning a new building in this direction by a proper attention of architects to its drainage system.

To householders and persons about to build a house I would give the general advice to have only few plumbing fixtures, as few as they can possibly get along with, but to have these of the very best quality and fitted up in the very best manner. It is much better to have only one water closet in a house, used constantly by all its occupants, and therefore frequently flushed, than to have half a dozen or more, each used only little.

It has recently been proposed by some, in view of the great danger to health from defective plumbing, to arrange all fixtures in an annex, separated from the living and sleeping rooms of the house. This would be not only inconvenient but impracticable in cold climates and seems

entirely unnecessary. All that needs to be done is to remove plumbing fixtures from sleeping rooms, as sewer gas entering these through leaky joints or defective traps and fixtures, would be much more dangerous to persons inhaling it during sleep than during hours of active exercise. Wherever possible, it is desirable to locate water closet apartments and slop sink closets so as to be cut off from the main part of the house. This would involve the separation of the water closet from the bath room, such as is common in Europe, but little known in this country, and which arrangement I am inclined to favor, especially in the case of a house, occupied by a large family, and having only few plumbing fixtures.

If proper regard were paid to the ventilation of rooms, containing plumbing fixtures, the risk from sewer gas would be infinitely reduced. Unfortunately, it has hitherto been the habit with most people to care more for the bright look of their fixtures, for deco-

rated china ware, costly marble slabs, silver-plated faucets, chains and tubs, for handsomely finished woodwork around bowls, water closets, sinks, than for the proper trapping and ventilating of such apparatus. Tight woodwork around bowls, tubs, sinks, slop hoppers and water closets, which is the rule in ninety-nine out of every hundred houses, forms harboring places for vermin; they in time accumulate dust and become exceedingly filthy, damp and foul smelling. The encasing of plumbing fixtures should be discouraged for sanitary reasons. Dampness and nasty odors can be prevented by keeping such spaces entirely open so that a free current of pure air sweeps around the fixtures, the most remote corner of which is thus made accessible to servants for cleaning purposes. But even with good sanitary appliances, properly ventilated and connected with self cleansing traps and waste pipes the householder should not forget that constant care and watching is imperative, as well as a thorough cleansing and scrub-

bing as often as once a week and preferably oftener.

Sufficient hints will be given in the following pages as regards the merits and defects of the various plumbing fixtures, especially the different types of water closets, to guide the householder in selecting proper and satisfactory appliances. In regard to the selection of a proper water closet—and, in fact, of every plumbing fixture—a certain embarrassment arises to every householder, in so far as almost every manufacturer naturally thinks his goods the best and safest to be used. Should the householder be unable to make a selection from his own judgment, he should consult an architect or sanitary engineer of reputation. Should he decide from personal opinion and examination of closets, let him bear in mind that closets almost without exception present a good and cleanly appearance in manufacturers' showrooms. The real test of the efficiency of a water closet is some months' severe use in a frequented place (which, however, should

be under constant supervision of a janitor). In this connection I would advise to choose none but the very best apparatus for the use of the servants. A servants' water-closet is likely to receive a rougher treatment and less cleaning than closets for use of the family; closets with movable machinery (pan, valve and plunger closets) are especially objectionable, as they frequently get out of order; no cheap kind of hopper should be used. An automatic flushing arrangement for servants' and children's closets will secure better cleanliness than arrangements to be worked by hand.

In speaking of water closets in general further points of importance for the selection of such apparatus will be mentioned.

WASH BASINS.

Beginning with wash basins, little of sanitary importance may be said with regard to them. If properly fitted with waste pipes of proper size and material and efficiently protected by a good trap,

they may be considered perfectly safe conveniences in dressing rooms. Their use in sleeping apartments, and in closets or boudoirs near bedrooms without independent ventilation, is attended with considerable risk, and the habit of putting stationary lavatories in such rooms, which has become so general nowadays, should be earnestly discouraged, especially for such rooms, as are not continually occupied (summer residences, hotels, &c.).

Wash basins are mostly made in earthenware, this material being the cleanest and best for the purpose. Iron works, however, manufacture cheap iron washstands, plain, painted, galvanized, or enamelled, which may answer for office use, for prison cells, &c. Copper basins are rarely used.

Earthen bowls are attached by brass basin clamps to marble slabs, the joint between them being made tight by means of plaster-of-Paris. To prevent damage to ceilings the bowls are provided with a number of holes near the upper rim, lead-

ing to a short horn, to which the lead overflow pipe is attached. Some bowls have a "patent" overflow, a concealed channel in the side of the bowl.

The outlet of bowls is commonly closed by means of an india-rubber, brass, or plated plug, to which a chain is attached. The annoyance caused in lavatories of public places by too frequent breakage of the chain, necessitating the removal of the plug by placing the hands into the dirty water of the bowl used by some unknown person, has led to the invention of a number of valve wastes for bowls. In most of these, as for instance, McFarland's, Foley's, Boyle's valves and the Boston waste, the outlet is closed some distance away from the bowl, thus leaving the bowl in connection with the valve chamber, which, after each use, remains coated with soapsuds and foul slime. At the next use of the bowl the clean water will mingle with this waste matter and become soiled even before use. Moreover, the valve chambers

get more or less foul after use, and emit noxious smells into the rooms.

The only device which closes the bowl directly at its bottom is "Weaver's waste." By simply touching a knob, connected with a lever, the stopper in the bottom of the bowl is lifted and held in place.

Jenning's "tip up basins" also do away with chain and plug and are very convenient for use, as the basin is emptied by simply tilting it, thus discharging its contents into a bowl underneath, which is concentric with the upper basin, and to which the trapped waste is attached. It appears at first sight to be a cleanly device, but it gradually accumulates foulness in the lower basin, which receives no special cleansing, and for this reason tip up basins are not to be recommended, except where a stricter regard to cleanliness of plumbing fixtures is paid than is usual in most households.

The objection raised against most valve wastes for bowls, namely, that the walls remain coated with a more or less

foul slime after emptying the bowl, is also true in regard to the bowl itself. In private houses these are, of course, well taken care of and daily cleaned; but in public lavatories, used rapidly in succession, a decided lack of cleanliness is felt. An entirely new departure in wash bowls, so far as this country is concerned—for it has been manufactured and sold in England—would be a *flushing rim lavatory bowl*, supplied with hot and cold water through a nozzle, to which both supply pipes are attached. By opening either faucet, hot or cold water, as desired would enter the bowl, simultaneously at all sides, and give it a thorough downward rinsing flush. The outlet of bowl may then be closed and the bowl filled with clean water. With such a flushing rim bowl some of the valve wastes would become unobjectionable even to the most fastidious.

To make the flushing rim lavatory perfect in neatness and cleanliness, the marble slab, to which the bowl is clamped, should be supported by hand-

some brackets of iron, brass or marble, leaving off all carpentry underneath. The floor under the bowl and the rear wall may be neatly finished in white tiles, or in cement or terrazzo floor, so as to be impervious, thus doing away with the safe lining underneath the bowl. If tiling or a terrazzo floor is considered too expensive, a well finished hardwood floor should be used.

The arrangement suggested for fitting up lavatories applies equally to common bowls. Hitherto more or less tight woodwork has been used to encase the space under wash bowls in order to hide from view traps, supply and waste pipes, safe linings, drip pipes, etc. Such tight unventilated spaces with dark corners must necessarily accumulate dirt, and become damp from leaky fixtures, and nasty in general. With first class plumbing work it is unobjectionable to have lead pipes and traps in sight: leakage is easily detected, and cleanliness of servants better enforced where there is plenty of light and air around a wash basin.

BATH TUBS.

Bath tubs are made of wood, or wood lined with galvanized sheet iron, or with zinc or heavy copper, tinned and planished, or nickel plated, of cast iron with porcelain enamel, and of stone ware. Any of these may be used, the selection depending chiefly upon their cost and upon the personal preference of house owners. For private residences copper bath tubs are used more than any others, the weight of the copper being from 16 to 20 oz. per sq. ft. for the best tubs. Enamelled iron tubs are also used extensively, especially in hospitals, asylums, &c. The porcelain bath tubs, although perfectly non-absorbent, most cleanly and attractive in appearance are not much in use, being very expensive, heavy and clumsy.

For bathing establishments enamelled iron and copper tubs are not to be recommended. the former losing their enamel by continued use, the latter being easily knocked out of shape and requir-

ing constant attention to keep on them a bright polish. In such places earthenware tubs will answer very well, being easily cleaned, and as they are used rapidly in succession they do not chill the water after the first bath, an objection raised sometimes against marble or porcelain tubs in private houses. Tubs in bathing establishments are often constructed of brickwork, lined with slate, or with white tiles or marble flags.

Many devices have been introduced to do away with the chain and plug arrangement of tubs, which device gets unclean from soapsuds here as in the case of wash bowls. Such improved bath wastes are, for instance, Weaver's, McFarland's, Foley's, H. C. Meyer's, Jennings', Stidder's and others. None of these is preferable to the "standing overflow," a most simple and cleanly contrivance, consisting of a tube of same bore with the bath waste pipe, with a trumpet-shaped mouth at its top, which tube is inserted in place of the plug at the bottom of the bath tub. It renders a special overflow pipe

unnecessary. The only objection, sometimes made against it, is that it may be in the way while bathing, especially with short, so-called "French" bath tubs.

While it is not my intention to consider the supply of hot and cold water to fixtures in general, nor to discuss the relative merits of ground cocks, compression bibbs and self-closing faucets, I must briefly touch, for reasons that will appear hereafter, upon the manner of supplying water to bath tubs.

If the hot and cold water faucets are placed near the top of the tub, the hot water speedily fills the bath room with steam (although this can be partly overcome by using a double bath cock with only one supply inlet); the noise of the falling water is also sometimes objected to. To avoid this inconvenience the supply has been made to enter the bath, hot and cold water mixed, through the same hole that serves as an outlet for the foul water. Thus soapsuds and filth coating the waste pipe and left there from the time the bath was last used, mingle

with the clean water. Such a device is unsanitary and must be utterly condemned.

If it is desirable to avoid the steam or noise in filling bath tubs, the supply inlet may be placed at the foot end of the tub, near its bottom. An advantage which this arrangement offers is that servants cannot draw water into pails or pitchers in a bath tub, a frequent cause of the chipping off of the enamel of iron tubs and the bruises made in the sides of copper tubs. It appears, however, that such a location of the supply inlet below the water line of the bath tub is, in certain cases, endangering the purity of the water supply. This risk always occurs whenever the bath tub is supplied directly from the rising main and the pressure of water is insufficient to supply at all times the upper stories of city houses. The *American Architect* of 1882, in calling attention to this danger (which danger is well known to exist in the case of water closets flushed directly from the service pipe), says, as follows:

“Thousands of fixtures are in daily use which are liable to have their supply fail altogether on certain days and hours, or to have it withdrawn temporarily by the opening of a faucet below. All such fixtures are exposed to the worst consequences of intermittent supply. If any person having access to fixtures so placed will try the experiment of opening a faucet at the time of low water, the rush of the air sucked back into the pipe will be plainly heard, or by placing the finger over the mouth of the faucet the inward pressure can be felt. Even where the head is considerable, an artificial lowering may be, and often is, caused by the opening of faucets in the lower stories, which will leave a vacuum in the pipe supplying the upper fixtures, and in such cases substances near the mouth of the upper faucets are liable to be sucked through them into the supply pipes. We have known the opening of a pantry cock in a lower story to siphon out in this way and discharge into the pantry sink the entire contents of a bath in a room

above, much to the amazement of its occupant. The bath happened to be fitted with a bottom supply."

This may even happen with a supply from a tank in the attic, and the only means to prevent the occurrence would be to run special lines of hot and cold water from boiler and tank respectively to the bath inlet, or else to place a check valve in the cold water supply to the bath, which remedy, however, cannot be relied upon to work for ever.

There are many varieties of tubs, used for personal cleanliness, such as foot tubs, hip baths, bidets, shower baths, &c. They need no further explanation, as the principles for the sanitary construction of bath tubs apply equally well to them.

Bath tubs of wood, lined with metal, necessarily require some exterior finishing woodwork, which also serves to hide from view the supply pipes, the overflow, trap and waste pipe.

In Europe, metal bath tubs are made sufficiently heavy to stand without a casing. This method of fitting up bath tubs

has much to recommend it from a sanitary point of view; such bath tubs stand free on the floor, perfectly accessible and with all pipes in sight, which seems entirely unobjectionable. Iron porcelain lined bath tubs are sometimes left without woodwork in our hospitals and asylums and give complete satisfaction.

LAUNDRY TUBS.

Laundry tubs are made of various materials, such as wood, wood lined with sheet lead, enameled or galvanized cast iron, cement stone, soap stone or earthenware. Wooden tubs are objectionable as this material readily absorbs the dirty water and becomes foul, emitting a close odor when not in use. Being alternately wet and dry they are liable to leak and will quickly rot. Cement stone laundry tubs are cheap, durable and cleanly. They have no seams, each tub being manufactured in one piece, and therefore will not leak. Galvanized or enameled iron and soap stone trays are equally good and much in use. The white crock-

ery or "ceramic" tubs are undoubtedly the neatest, and are always perfectly clean and sweet. They are not subject to wear or leakage, nor do they absorb dirty water, and therefore do not become foul from use. They are, of course, more expensive than any of the others. Wood-work about wash tubs should be dispensed with as much as possible, and the tubs treated in this respect as suggested in general for plumbing fixtures.

KITCHEN AND PANTRY SINKS, LAUNDRY AND HOUSEMAID'S SINKS.

Sinks are made of wood, of wood lined with lead, or with copper, of cast iron, which may be galvanized or enameled, of copper, soap stone, slate or earthenware.

For pantry sinks tinned and planished copper is generally used, being preferable to porcelain or soap stone sinks, as glass and crockery is not as liable to breakage in them.

For kitchen and laundry sinks soap stone or iron is much used. Galvanizing or enameling the iron much improves the

appearance of the sinks, but even these protective coatings wear off in time, and then the iron rusts rapidly. Of late earthenware sinks have been manufactured up to large sizes and are undoubtedly the cleanest and neatest of all kinds.

Housemaids' sinks, used only to draw water, may be of small size and look most cleanly when manufactured in earthenware, although other materials are often employed.

Sinks should be provided with strong, metallic strainers, either open or plug strainers. In both cases the strainer should be securely fastened to the sink so as *not to be removable* by servants, in order to prevent obstructions of the waste pipe and trap. With plug strainers it is important that the sink should have an overflow pipe of sufficient capacity to carry off the full supply, in case the supply cock should be accidentally left open.

In most houses kitchen sinks are encased in tight woodwork, and conse-

quently a close, damp and often noticeable in the compartment under a sink. This method of fitting up sinks is decidedly objectionable, and the common practice of using such unventilated closed spaces under a kitchen sink for the storage of kitchen utensils, or what is worse, cleaning rags, etc., should be strongly condemned. The space underneath a kitchen sink should be free to light and ventilation, and readily accessible for frequent cleansing. The sink may be supported by brackets, properly fastened to the walls, or it may rest on legs. The floor under the sink and the rear wall may be finished with white Minton tiles, which makes a neat and most cleanly arrangement.

The remarks just made as to the desirability of keeping the spaces under sinks entirely open apply also to pantry sinks and housemaid's sinks.

GREASE TRAPS.

Through kitchen and pantry sinks a large amount of grease, derived from

washing dishes, etc., is emptied into the drainage system. This grease proves to be of all the waste matters in the house the most difficult to deal with. Being dissolved by hot water it passes the strainer of the sink in a fluid condition, but soon becomes chilled, adheres to the sides of the waste pipes or drains, lodges in traps, and becomes putrid and offensive.

If the drain inside and outside of the house has a very good pitch, the grease will probably be carried far away from the house before becoming solid. This is more likely to happen where sinks have plugged outlets, as the rush of the water carries the grease very far. The ammonia of urine will remove grease, and thus pipes receiving above the point where the waste from the kitchen or pantry sink enters the cellar drain a water closet or urinal discharge are often found to be comparatively free from grease.

But in large houses, or hotels, &c., the grease should not be allowed to enter

the house drain at all ; it should be intercepted by a proper grease trap, placed as near to the sink as the locality may permit. The grease trap may be placed either *within* the house, in the basement or directly underneath the sink, or else *outside* the house. The latter arrangement is much the best, provided the distance from the kitchen sink to the grease interceptor is not too great, otherwise the grease would congeal on its way to the interceptor. A circular tank made of bricks, laid in hydraulic cement, should be constructed of dimensions depending somewhat upon the size of the house. It should be large enough to allow the water time to cool. Its overflow pipe consists of a quarter bend, or better, of a T branch, dipping at least six inches below the water line, in order not to disturb the grease in the intercepting tank. *This grease trap should be frequently cleaned and inspected.* The grease, floating on top of the water, can easily be removed. Efficient ventilation by a large vent pipe should be pro-

vided. Wastes from kitchen and pantry sinks only should discharge into the grease trap.

If inside of the house and in the basement, the grease trap may be made of earthenware, of wood lined with heavy lead, or of copper. But such a grease trap in the basement cannot be recommended.

If directly under the sink it may be made of enameled or galvanized iron, of copper or of crockery ware. A number of patented sinks have an iron receptacle for grease immediately below and attached to them. It is doubtful whether these tanks under sinks can be made of sufficient size, without becoming clumsy, to allow the grease to cool and congeal. Unless properly attended to—and the kitchen sink is liable not to be kept perfectly clean by the servants—grease traps inside of a house constitute, in my opinion, cesspools on a small scale, holding fatty waste matters which readily become putrid and offensive. If there is no convenient place for an outside grease

trap, better use none at all and trust to the action of the alkalies to "cut" the grease in the pipes. A valuable cleansing agent for pipes, where the use of a grease trap is omitted, may be found in occasional flushing with hot solutions of common washing soda, or better, of potash.

SLOP SINKS AND SLOP HOPPERS.

We have hitherto considered only those fixtures which receive foul water unmixed with discharges from the human system. Slop sinks and slop hoppers, as well as water closets and urinals, intended to convey to the drain these foul discharges, are more liable to become filthy outside and inside, unless carefully attended to.

Slop hoppers are provided on bedroom floors to enable servants to empty chamber slops into them. They must be flushed, after each use, by a sufficient quantity of clean water from a cistern, or else at frequent intervals by automatic flush tanks, to expel the foul water

from the trap and to wash the inner sides of the hopper bowl or sink. Considering the character of the foul water poured into such vessels, an efficient flush is fully as necessary for them as it is for water closets or urinals.

Slop sinks are made either of enameled cast-iron or of earthenware. Their outlet should always be provided with a fixed strainer to prevent any obstruction of the trap or the soil pipe by carelessly introduced articles, such as scrubbing brushes, etc.

Instead of a deep sink a combination of a sink and a hopper, such as Merry's slop-hopper sink, is sometimes used, and, if provided with a strainer, it will answer very well.

An earthen bowl, with improved flushing rim, placed on top of an iron or lead hopper, will make a cleanly device. The neatest arrangement is a slop sink, made in one piece of earthenware, enlarged at the top to a square sink, and provided with a flushing rim and liberal supply of hot and cold water.

Slop sinks and hoppers should be treated in their external finish similar to kitchen sinks and water closets. Air and light should find easy access to them; there should be no tight woodwork around the apparatus with the usual amount of dust and untidiness. The floor may be of white tiles or of cement, and the walls may be laid with tiles or with enameled bricks.

If water closets without movable parts (hopper and washout closets) are fitted up without woodwork (except the seat) they may also serve the purpose of a slop sink, provided that the flush is not forgotten after emptying slops. The practice of using pan, valve or plunger closets, to get rid of chamber slops, is decidedly objectionable. These closets are most always encased in woodwork, which becomes impregnated with the foul water, carelessly emptied and often spilled. In the case of valve closets, the overflow pipe from the bowl is fouled and the same is true for plunger chamber and overflow of plunger closets.

URINALS.

No fixture is so liable to become unclean and foul smelling as a urinal, owing to the rapid decomposition of the urine. A small amount of urine spattered over is apt to become quite offensive. Urinals, therefore, require a very liberal amount of flushing water, running either in a constant stream, or else delivered automatically through flush tanks at frequent intervals. The material for urinals should be non-absorbent and non-corrosive.

Swinging and lipped urinals have been much used in modern private residences, but I should certainly advise doing away with them entirely, as a properly constructed water closet may safely take their place.

For offices, however, and public places, such as hotels, schools, railroad depots, places of amusement, etc., they become a necessity, but should be under constant supervision of a conscientious janitor, and should receive a thorough cleaning

with hot water and soap, at least once a week, and preferably oftener. The ventilation of urinal apartments should also, for reasons stated above, receive careful attention.

Three kinds of urinals are in use, viz.: single lipped bowls, fastened along a wall, or in corners, and generally known as "Bedfordshire" urinals; urinal troughs and round urinals.

Lipped urinal bowls are made in earthenware and of enameled iron; the latter, however, cannot be recommended, as the enamel is apt to scale off, leaving the iron to corrode quickly. A number of porcelain lipped urinals is frequently placed along a wall, with board, slate or marble partitions between them. They are sometimes flushed by a stop-cock, to be turned by hand, which is an unsatisfactory device. Not only is the opening of the stop-cock frequently neglected, especially in public places, but a flush directly from the supply pipe will, in most cases, be insufficient thoroughly to rinse the sides of the urinal. If located

in upper stories, the pressure is at times insufficient to fill the pipes, and air, possibly tainted and filled with disease-breeding germs, may be sucked into the supply pipes, on opening the stop-cock.

A much better flush can be obtained by supplying flushing water to the urinal from a special cistern, worked by chain and handle. For public places, however, where urinals are mostly used, I consider an automatic arrangement as being much superior. This may be accomplished by operating the flushing cistern from the door leading to the urinal; or else a treadle-action flushing apparatus may be used. Both arrangements are liable to get out of order, and preferable to either is a siphon tank, such as Field's annular siphon, or Guinier's siphon tank, and tilting tanks, such as McFarland's tank and others.

Modified forms of the Bedfordshire urinal have recently been manufactured both in England and in this country, which seem to possess many advantages

over the common forms, the bowls being shaped so as to hold water (similar to a wash-out closet) to a certain depth. Such improved urinals are, for instance, Stidder's urinal and the Armstrong urinal. With them the urine is immediately diluted with water, and consequently it is much easier to keep the bowl clean by frequent automatic flushing.

Urinal troughs are made of wood lined with lead, or of galvanized or enameled cast iron, or else of slate.

Round urinals are adapted to out-of-door location, in parks, etc.; they have a large circular bowl, holding a body of water, with a number of projecting lips around its circumference, separated by suitable slate partitions.

A constant stream of water should trickle into trough or round urinals, in order frequently to change the water in the bowl, and to secure an immediate and thorough dilution of the urine.

A modification of the trough urinal is sometimes constructed as follows: The

back wall of the urinal apartment is suitably prepared so as to be impervious and non-absorbing. No material is better than slate for this purpose. A horizontal supply pipe is fastened to the wall about five feet from the floor, running from one end of the trough to the other. It is provided with a large number of openings, or sometimes with a water spreader, from which the water is constantly trickling down the walls. The floor should be made equally impervious, and should have a gutter with sufficient fall to carry off the water mixed with urine. The whole floor should be constructed sloping toward this gutter. Suitable stands or gratings are sometimes provided at the stalls, which are separated by marble or slate partitions. The outlet in the gutter must be provided with a strainer to prevent obstructions of the trapped waste pipe attached to it.

WATER CLOSETS IN GENERAL.

The most important and useful plumbing fixture in a house is the water closet.

Water closets should be in all houses that make any pretensions towards convenience. That they are a vast improvement over the old-fashioned, offensive privy vault in the back yard, everybody will acknowledge. But it is equally true that, unless of a good pattern, properly fitted up, properly used, carefully watched and frequently cleansed, they may become not only the sources of foul smell but also the cause of disease.

Leaving aside the question of the pollution of the soil and of well waters, of which the privy vault must sooner or later be the cause, it is in itself a nuisance and an abomination. In cold weather and during rain storms persons are liable not to use it when they ought to, and trouble of the digestive organs is sure to follow, as every physician knows. This is especially the case with females and with delicate children. Sick persons and invalids may suffer severely from exposure to the weather. Add to this the often unbearable stench emanating in hot weather from such

vaults, and it will be readily seen how superior in point of convenience, health and cleanliness an indoor water closet is.

There are other improved devices for receiving faecal matters, such as earth closets, ash closets, tubs or pails, which are far preferable to privies, and should be recommended wherever water is scarce; but these do not properly belong to my subject, which refers only to the "water carriage" system.

There is an endless list of water closets, and each year increases the number of newly invented and patented articles. It is, of course, impossible, nor is it even desirable, that my paper should give a complete description of all of them. I shall limit myself to describing the chief features of the various *types* of closets, mentioning a few examples of each type.

After reviewing the different patterns of water closets in use we shall speak of the general arrangement of the water closet apartment with respect to light and air.

The essential points to be considered in examining water closets are: the shape of the bowl or vessel receiving faecal matter; the apparatus for discharging the contents of the bowl; the manner of trapping the water closet; the manner of flushing the bowl and the trap; and the ventilation of the water closet.

The less *surface* a water closet has *exposed to fouling*, the cleaner and better will it be. All foul discharges should pass into water as quickly as possible. Thus the fouling of the sides of the vessel will be efficiently prevented and the water will have a tendency to deodorize the excrements. All water closets holding a large body of water in the bowl (valve and plunger closets, wash-out closets and latrines) have this advantage. In other closets, where the body of water is in the trap (hoppers), this latter should be as near as possible to the bowl (short hoppers are preferable on this account), and the rear side of the vessel should be designed nearly vertical

and straight to prevent foul matter from soiling the bowl before passing into water.

A further requirement is *durability and simplicity of the working apparatus*. The less moving parts a water closet has the better will it be. We must have regard to the rough usage to which such fixtures are sometimes subjected, especially in public places. Complicated or delicate mechanisms frequently get out of order, or fail to work properly under children's or servants' hands. Nobody can deny that, so far as this point is concerned, hopper and wash-out closets are vastly superior to pan, valve and plunger closets.

Each water closet should be separated from the drain or soil pipe by an *efficient trap*, placed either above or below the floor, and protected, whenever necessary, against siphonage. I consider one good trap as entirely sufficient, and do not have much faith in the additional water seal afforded by the water in the pan of a pan closet, or the water in the bowl of a valve or plunger closet. The

copper pan quickly corrodes through the action of sewer gas in the container, and the flap valve gets leaky in time, while with plunger closets flushed from a cistern the bowl may lose its water if the outlet is imperfectly closed, as may happen, when paper remains clinging to the seat of the plunger. Wash-out closets are sometimes provided with a double trap, which is an obstacle to a proper flushing, and which may accumulate filth in the hidden and mostly unventilated space between both traps. I consider a double trap as unnecessary here as on the main house drain. Wash-out closets, the basin of which is shaped so as to form an efficient trap, and short hopper closets with trap above the floor, should not have a second trap (of either iron or lead) underneath.

The contents of a water closet trap should be thoroughly changed at each use of the closet, which can be accomplished by an efficient and liberal flush. This leads us to consider the supply of water to such apparatus.

A water closet should have a *copious supply* of water completely to wash at each use the bowl and trap as well as all surfaces coming in contact with foul matter. I do not, however, wish to be understood as favoring *reckless waste*, for it is well known that allowing the water to run continuously through a water closet cannot be regarded as *flushing*. Two or three gallons properly applied at each use will cleanse a water closet more thoroughly than an uninterrupted trickling flow of water. In order to be efficient the *flushing water should come down "in a sudden dash."* To make the flush effective the supply pipe from cistern to bowl should be of large diameter, never less than one inch, and increasing up to 1½ inches as the head (or height of bottom of cistern over the bowl) diminishes. The force of the flush largely depends upon the shape of the bowl and upon the head of water available in each case. With closet bowls, circular in shape, a flush introduced in the direction of the tangent will whirl around its cir-

cumference, losing its force without effecting much cleansing. An oval bowl provided with a fan flush is a vast improvement. The best bowls are those provided around the upper edge with a proper "*flushing rim*," into which the water from the supply pipe enters simultaneously at all sides, and is directed to rush vertically downward, thoroughly washing the sides of the closet and retaining sufficient force to expel the foul contents of the water closet trap.

The mode of flushing a water closet from the main supply pipe of the house is decidedly objectionable, especially with closets located in upper stories of city houses. If water is drawn from a faucet in the basement the pressure is often reduced so much as to create a slight vacuum in the upper part of the pipe. If the valve of a water closet happens to be opened at such times, air, if not foul matter, rushes into the pipe from the bowl. Thus the purity of the drinking water is endangered, while the closet remains without a flush. This risk can be par-

tially avoided by the use of a check valve on the supply pipe to the closet valve. Such check valves, however, are not reliable and often fail to shut properly.

Water closets should be flushed from cisterns, never directly from the main supply pipe. But cisterns intended for storage of water to be drawn for drinking and cooking purposes should not be used for flushing water closets. In all cases the use of a *special cistern* for each closet or for a group of closets is recommended. Such water closet cisterns are manufactured in great variety by almost all water closet makers.

They are supplied with water either from the rising main or the large tank in the attic, by ball-cocks, made sufficiently strong to withstand the maximum pressure of water. In their simplest form cisterns have only one compartment, with a pipe attached to their bottom, leading to the closet, and with a valve closing this outlet of cistern, operated by a chain and lever. An overflow pipe is provided to prevent accidents through leakage of

the ball-cock. Such tanks are only adapted for hopper closets, and should not be used where water is scarce, as with them a large waste is likely to occur.

Closets, holding water in the bowl (pan, valve, plunger and washout closets) require an "after flush" to refill the bowl, and the cisterns should be provided for such purpose, with a service box, holding a certain quantity of water. The outlet from the cistern to the service-box must be closed by a large sized valve in order to secure a quick filling of the service-box.

Cisterns, arranged with a view to prevent the waste of water, are desirable wherever the water supply is apt to become scanty during the hottest and coldest months of the year. They have, in this case, three compartments, a large tank, supplied by a ball-cock, a measuring cistern, holding the quantity of water fixed for each flush, and a service-box for the after flush.

Water waste preventers for hoppers, however, require only two compartments,

the receiving tank and the measuring cistern.

Water closet cisterns are operated either by the common pull-up arrangement, a handle being connected to one end of a lever, the fulcrum of which is firmly secured to the floor, while the other end of the lever is connected by a brass safety chain to the lever operating the cistern valve. Such an arrangement is common for pan, valve and plunger closets. Or else the lever and valve is operated directly by a chain, with tassel or ebony handle, which arrangement seems best adapted to hoppers and wash-out closets (and slop sinks).

An automatic "seat arrangement," in other words, the operating of the cistern by a depression of the seat through the weight of the person, seems most suitable for public places, schools, factories, &c., where people using the closet are apt to forget to attend to the flushing. With the seat arrangement cisterns with double compartments and double valves must be used. A service-box is attached to

the cistern for closets requiring an after flush. The depression of the water closet seat opens the valve from cistern to measuring box, which quickly fills up; relieving the seat of its weight causes the valve to close, and the outlet of measuring box to be opened, allowing the contents of the latter to rush into the water closet bowl. As the valve closing the outlet of the measuring box is of large size (generally 4 inches) the water rushes into the service box quicker than it passes out through the $1\frac{1}{4}$ or $1\frac{1}{2}$ inch supply pipe, thus securing to the bowl the after wash.

The annoyance frequently caused by the leakage of such cistern valves has led to the invention of other forms of water closet cisterns. Many of these are made to empty by siphons, such as Bean's flushing cistern, Purnell's patent siphon water waste preventer, Emanuel's double siphon water waste preventer, Braithwaite's siphon cistern, Brazier's cistern and others.

Bean's flushing cistern, lately intro-

duced into this country, is very simple and efficient in its action. It contains an annular siphon, very much like Rogers Field's siphon. The inner limb (usually of cast iron) is firmly fastened in the center of the cistern, passing through its bottom, where it is connected with the supply pipe to the closet bowl. The outer limb, made of copper, with a dome head, allows of a vertical movement around the inner limb, this movement being effected by a lever, working in a slot, one end of which is attached to the outer limb of siphon, while the other carries at its end a counterweight. A chain is attached to that extreme end of the lever holding the siphon, and the cistern is operated by a handle attached to the chain. By suddenly pulling downward the copper limb of siphon, water is forced over the top of inner limb and the siphon started at once. The outer limb is held down by the suction until all water is discharged, when the counterweight brings the siphon into its original position.

The tank is supplied with water by a

ball-cock, rising with the water; the inner limb serves as overflow pipe and renders a special pipe for that purpose unnecessary.

Bean's tank provided with an $1\frac{1}{4}$ to $1\frac{1}{2}$ inch pipe to the closet bowl is well adapted to flush earthenware flushing rim hoppers and slop sinks.

The double-siphon water waste preventer of Emanuel, London, is a cistern having two compartments, and a siphon of bent pipe, the shorter end of which opens near the bottom of the first compartment, while its large limb is carried to the closet bowl. The other compartment contains a smaller siphon pipe, the shorter limb of which opens into it, while the long limb is connected to the longer limb of the large siphon. Both siphons are started by forcing down a disc in the first named compartment connected to the lever, operated by chain and handle. This action forces water into the larger siphon, which quickly discharges the water contained in one compartment while the second siphon delivers as an

“after flush” the water of the other compartment.

Purnell's water waste preventer is a plain cistern, provided with a common siphon pipe, the longer limb of which passes through the bottom of cistern and leads to the water closet bowl. Near the bottom of cistern a branch pipe leads into the longer limb, reaching to within a few inches from the level of water in the cistern, where it is closed by a valve. This valve is attached to one end of a lever, the other end of which is operated by a chain with handle attached. To flush the closet, the chain is pulled, opening the valve, and thus water flows through the connection pipe into the longer limb of siphon, causing a partial vacuum, which starts its action. The siphon continues to discharge until the contents of the cistern are withdrawn, when it completely breaks. This cistern and Bean's do not give (in their usual shape) an after flush, and are consequently only suitable for hopper closets, slop sinks or urinals.

Bean's tank, however, can be modified to give this after wash, where desired.

Among automatic arrangements for flushing water closets I mention flush tanks, working on the principle of the siphon, or tanks working by gravity. They are useful in railroad depots, schools, large factories, places of amusement, and in exposed localities, where standing water would be apt to freeze. Such tanks collect a continuous dribble from the supply cock until filled, their capacity being proportioned to the number of closets, and then discharge the full contents at once into the bowl (see chapter on flushing appliances).

The question of ventilation of water closets will be referred to later in speaking of the general arrangement of water closet apartments.

A properly trapped water closet, provided with a good flush from a special cistern, with a flushing-rim bowl of improved shape, located in a well ventilated apartment, judiciously used and

well taken care of, should be inoffensive to sight or smell.

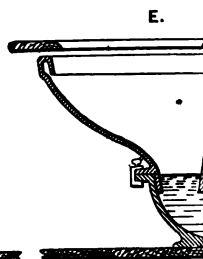
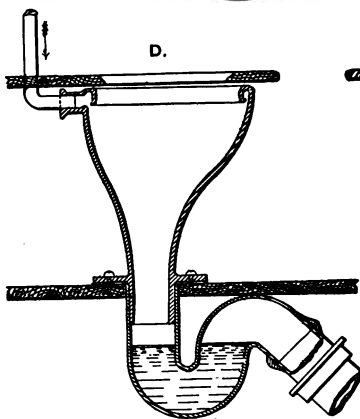
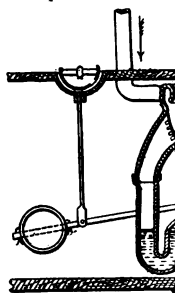
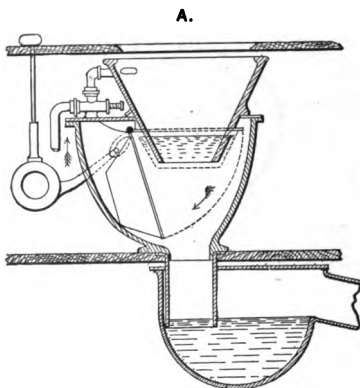
Bearing in mind the general principles just stated, we will now examine the various types of water closets. There are six distinct classes viz.: *pan closets, valve closets, plunger closets, hopper closets, washout closets and trough closets (latrines).*

These types are illustrated in Fig. 4 and Fig. 5. The closets shown, however, are not intended to illustrate any manufacturer's special make; they merely represent the various *types of closets*.

A shows the pan closet, flushed by a valve, supplied directly from the rising main, its bowl being closed by a pan, held in place by the counterweight, the closet outlet being trapped by a large D-trap under the floor.

B is an illustration of a valve closet, with cistern flush, the bowl having improved flushing rim and a special trapped overflow pipe, and being closed by a flap valve held in place by the counterweight; the container is provided with an escape



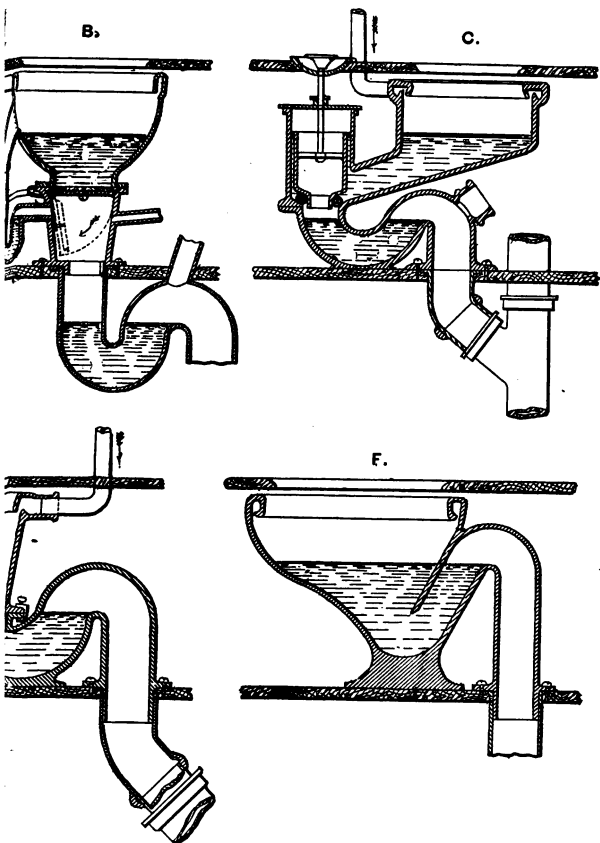


A Pan closet.
B Valve closet.

TYPES OF

C Plunge
D Long
E Plunge

Fig. 4.



WATER CLOSETS.

Short hopper closet.
Washout closet

E Short hopper closet.
F Washout closet.

pipe for foul gases, and the S-trap under the floor has a vent pipe attached to prevent the loss of its water by siphonage.

C is a plunger closet with improved flushing rim bowl, supplied with water from a cistern, the outlet of the closet being on one side and closed by a plunger working in a chamber and to be operated by knob and pull. The trap is above the floor and provided with a hub to attach a vent pipe.

While these three closets are operated by more or less complicated machinery, the three following types are free from any movable parts.

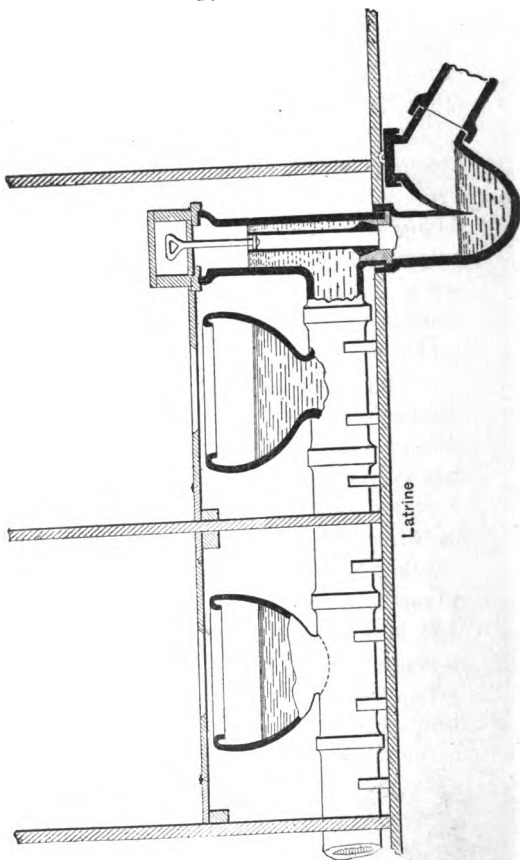
D is a long flushing rim hopper having an S-trap under the floor.

E is a short flushing rim hopper with S-trap above the floor.

F is a washout closet, holding water in the basin, which also serves as a trap.

Fig. 5 shows the general characteristics of a trough closet (latrine).

Fig. 5



PAN CLOSETS.

To this class of closets belong the Philadelphia valve closet, the Bartholomew valve closet, Harrison's "Empire" water closet, Carr's "Monitor" closet, the Lambeth pan closet, Underhay's pan closet, Banner's closet, Craigie's "Eureka" closet, Craigie's "Century" closet and many others.

The name "valve" closet is an improper one, and leads to confounding these closets with those of the second type. The name is derived from the usual manner of supplying the flushing water to the closet, by joining the supply pipe to a more or less slow shutting valve, worked by the pull or handle of the closet. These valves are mostly unreliable, wear out and leak, especially when subjected to varying pressure from the street main. Pan closets may, however, be flushed by a special cistern with lever arrangement, and therefore the above serious defect is not one characteristic to these kind of closets.

The real defects of the pan closets will be at once apparent by inspection of Fig. 4. A. The excrements are received in a bowl, closed at the bottom by a copper pan, holding a few inches of water and forming a seal against the air from the container. The contents of the bowl or pan are discharged by tilting the pan by means of a lever, while a flush is simultaneously started. This pan works in an iron receiver or "container," upon which the bowl is usually fastened with putty. The outlet of the receiver is trapped by the common S-trap, although it is not uncommon to find in old houses a D-trap under the water closet, a second "container" of foul matters. The foulest part of the pan closet is the receiver, for the solids gradually accumulate on its sides, as these receive no washing from the flush. The filth soon undergoes decomposition, and the resulting gases, having been confined by the double water-seal of the pan and the trap, are expelled into the apartment at each use of the closet. They

also frequently find an exit at the hole, through which the spindle, tilting the pan, passes. And finally, the putty joint between bowl and receiver may become untight and afford means for the passage of sewer gas. The flush is insufficient in most pan closets to clean the bowl; it certainly loses all its force before reaching the container, foulness accumulates here and excremental matter lodges in the trap, as the flush is not strong enough to drive it out through the dip or water-seal.

Some of the enumerated defects may be obviated by enameling the inside of the cast iron receiver; by ventilating it by an inlet pipe for fresh air and a vent pipe; by having special flushing arrangements for the container; by using a bowl with an improved flushing rim or a fan spray, the water for the flush being derived from a special tank. But by all these costly improvements the *only* merit of the pan closet, its cheapness, is annihilated, and a better water closet may as well be used. As long as a house is fitted with pan closets, of whatever pattern,

it may be said not to have reached the standard of safety from a sanitary point of view.

VALVE CLOSETS.

To this class belong the following water closets: The old "Brahmah" closet, Hellyer's improved valve closet, the Lambeth valve closet, Tylor & Sons' patent valve closet, Underhay's valve closet, Bolding's "Simple" valve closet, Carr's American "Defiance" closet, Mott's "Climax" closet, Mott's "Whirlpool" closet, Demarest's "Acme" closet, the Alexander water closet, the "Victor" sanitary valve closet, the Lambeth trapless closet, Tylor & Sons' trapless closet, Bean's valve closet and others.

The valve closets (Fig. 4. B) are certainly a vast improvement upon the pan closet. Instead of being closed by a pan, the bottom of the bowl is closed by a flap-valve, from which the closet takes its name. This valve is tightly held in place by a counterweight on a lever to which the pull is attached. By lifting

the pull, the valve, which is hinged, is turned downward, and allows the contents of the bowl to drop into the trap. The container is much smaller than in the case of pan closets. It generally has a ventilating pipe to remove foul gases. The bowl holds a large quantity of water into which the solids are dropped and instantly deodorized. It is provided with some of the best closets of this type, with a superior flushing rim, and is flushed by a special cistern. As the flap closes tightly against the bottom of the bowl this must be provided with an overflow which should have a trapped connection to the container. Unless some water is furnished to this trap at each flush it is liable to lose its seal by evaporation, thus establishing a direct connection between the container and the atmosphere of the water closet apartment. Such dribble to the trap of the overflow is supplied at each flush in the better valve closets. There is some danger of the fouling of the container. To prevent this the better closets have

the inside of the container enameled, and as a larger body of water rushes from the bowl through the container at each discharge, the danger is much less than with the pan closet.

If such closets are flushed from a valve the solids will be driven out of the lead trap only after repeated flushing. Better closets of this class have suitably arranged cisterns, which deliver quickly a large body of water to bowls with improved flushing rims, and thus the danger from foul matter being retained in the trap is much reduced. After continued use the flap-valve is liable to leak; excrements or paper may stick to it and prevent its tight closing, and all water will leak out of the bowl. Thus the additional water-seal is lost and the bowl is more liable to become fouled.

The Lambeth and Tylor's trapless closets are different from those just described. The outlet of their bowl is placed at the side, not at the bottom, and is closed by a vertical flap-valve hinged to

spindle and lever, and held in place by a counterweight.

Such valves may be less liable to be fouled with solid matters and may close more tightly on this account. The water rushing out of the bowl in a large body will effectually flush the outlet of the closet.

Both closets do away with the trap and rely for exclusion of sewer gas only upon the flap-valve and the water in the bowl. In speaking of traps under fixtures I have already stated that each fixture should have a trap, and I would much prefer dispensing with the additional water-seal in the bowl than with the trap underneath the closet. Such trapless closets are not safe, for should the mechanism of the flap-valve get out of order the house would be entirely open to the invasion of sewer gas from the soil pipes.

PLUNGER CLOSETS.

Among closets of this type I mention Jennings's closets, the Demarest closet, Mott's "Hygieia" closet, Moore's closet,

Zane's "Sanitary" closet, the California "Perfection" closet, Myers' Gale closet, Myers' China closet, the Hartford Glass closet, Myers' egg-oval water closet, Smith's "Arizona" plug water closet, Pearson's Twin basin closet, Smeaton's trapless water closet, Smeaton's "Eddy-stone" closet and others.

The characteristic detail of all these (see Fig. 4 C) is the plunger closing the outlet of the bowl, which is placed at the side of the closet. The foul matters drop into a large body of water in the bowl, are therefore partly deodorized and easily removed from the bowl. By lifting the plunger the contents of the bowl are rapidly discharged into the soil pipe, and the rush of the water, leaving the bowl, is so great as effectually to drive all matters through the dip of the trap. The latter must be efficiently protected against siphonage, which is more likely to occur with plunger closets than with the pan, valve, or hopper closets. The danger with closets of this class lies in the fouling of the plunger chamber. Waste

matters and paper may stick to the seat of the plunger or to its sides; the outlet will then be imperfectly closed, allowing the water to leak out of the bowl. Closets having a small plunger chamber are the better ones, not only because they will be cleaner, but because with large chambers the waste of water must necessarily be large.

Plunger closets flushed by a special cistern require no supply valve nor float in the plunger chamber, which, therefore, may be of smaller dimensions, and hence are superior to other closets of this type.

In some plunger closets a special spray arrangement is intended to wash the sides of the plunger and its chamber at each use of the closet, but, while it may be efficient, it tends to complicate the closet. The better closets of this class provide the top of the bowl with an improved flushing rim, or wash the sides of the bowl by an effective fan or water-spreader. In order to provide for an overflow the plunger is sometimes made hollow, and when trapped it is so arranged that the

water forming a seal is renewed at each flush. Otherwise it is liable to evaporate and this is especially dangerous with plunger closets that are trapless.

Trapless plunger closets are not safe for same reasons as stated for trapless valve closets.

In some closets an independent overflow is arranged. Most plunger closets are flushed by a valve, worked by a float in the plunger chamber. These valves are not always reliable, especially under varying pressures, and it is much better to flush these closets from a special cistern.

HOPPER CLOSETS:

There are many varieties of hoppers, made in iron or in earthenware. The latter are much preferable, and the former should never be used unless well enameled inside. Among hopper closets I mention Hellyer's long and short "Artisan" hoppers, Myers' "Niagara" hopper, Demarest's long and short earthen hoppers, Huber's long and short

earthen hoppers, Rhoads' hopper, Ivers' hopper, Harrison's drip tray bowl flushing rim hopper, the Lambeth "Cottage" closet, Smith's "Odorless" hopper, Henderson's Automatic water closet, Maddock's hopper, Moore's "perfectly odorless" sanitary closet, Watson's hopper and others.

Hoppers (Figs. 4, D & E) are sometimes liable to become soiled at the sides of the bowl, and for this reason have not become favorites with many. The hopper lacks the advantage of the pan, valve and plunger closets, in which the excrements drop immediately into a more or less large body of water, and thus carried in suspension by the water, are easily removed from the bowl by tilting the pan or valve, or by lifting the plunger. A good practice is to wet the sides of the hopper before use, and where the hopper is flushed by a special cistern such a device has been arranged to work automatically. The rear part of a hopper should be vertical and straight, so that matters will drop immediately into the water of

the trap without touching the sides of the hopper. The inside of hoppers should be very smooth, and for this reason, earthenware is much preferred to enameled iron, because the enamel scales off gradually. In order to have as little surface as possible exposed to fouling the sides of the hopper should be short, which is in some accomplished by having the trap above the floor. The apparent greater cleanliness of the pan, valve or plunger closets is simply a delusion. It is true, the hopper will sometimes have its sides soiled with excrementitious matter, when the supply or the manner of flush is inadequate. But the defect is in sight; it shows itself to the person using or in care of the closet, and it can easily be remedied by proper occasional application of hot water, soap and a scrubbing brush.

Not so with the other closets. The dirty matter may be out of sight, but it often remains hidden in those parts of the closet which are not easily accessible, and therefore never cleaned or inspected,

until a leakage occurs, or until some foul odor compels the householder to call for the plumber.

The great merit of hoppers lies in their simplicity and in the total absence of any mechanical parts which, sooner or later, fail to work properly, especially when the closet is carelessly used. Much depends with a hopper closet upon the manner of flush. The practice of turning a stopcock and thus introducing a feeble stream into the hopper, which whirls around its inside, is objectionable. Hopper closets should always be provided with *flushing cisterns* allowing a *bountiful supply* to rush vertically downward through a *large supply pipe* and a *well-shaped flushing rim*.

Rhoads' porcelain seated hopper is a cleanly device for hospitals, schools, factories, railroad depots, public buildings, &c., provided it is well flushed, and only where the apartment can be well heated in winter, as otherwise, the seat being cold, the closet is liable to be improperly used.

Hoppers with wooden rims for a seat, attached to the bowl will answer better than Rhoads' hopper in exposed places, the only objection being the possible absorption of urine through the wood.

WASHOUT CLOSETS.

I have grouped a number of recently invented water closets into this last class which I consider, *in principle*, far superior to any of the other closets for the following reasons: They are mostly made in one single piece of earthenware and are entirely free from any movable parts (see Fig. 4, F). Moreover, the bowl of many closets of this type is shaped in such a manner that its outlet or overflow forms a very efficient water-seal trap, thus obviating the necessity of a trap under the closet. All washout closets have their basin so shaped as to hold a large quantity of water; the advantages of such an arrangement have been already stated. A washout closet is in fact only a modified and improved form of hopper.

In England closets of the "washout"

type are preferred of late to other closets, and in this country quite a number of such closets have been introduced. Among closets of the washout type mention: The "National" side outlet closet, Owen's closet, the Lambeth "Flush-out" closet, Carmichael's "Washdown" closet, Woodward's "Washout" closet, Bostel's "Brighton Excelsior" closet, Dodd's Patent closet, Hellyer's "Vortex" closet, the "California" or Smith's "Siphon Jet" closet, the "Dececo" closet, the "Tidal Wave" closet, and others.

Different means are employed with the closets of this class to effect a discharge of the bowl. In many the downward rush of water directed through proper flushing rims so as to concentrate its main force at the outlet of the basin, drives the contents of the bowl into the overflow, and thus into the soil pipe ("Brighton" and "Vortex" closets). In others a jet of water is introduced into the outlet pipe and carries all water from the bowl, partly by the force of the jet, and partly by starting a siphoning action

(Smith's "Siphon Jet" closet). In still others a partial vacuum is created by different means in the outlet and a true siphonage established ("Dececo" and "Tidal Wave" closets).

LATRINES.

Latrines and trough water closets are frequently used in public places, schools, railroad stations, factories, hospitals, military barracks, etc. Latrines (Fig. 5) consist of a series of strong stoneware or cast iron porcelain lined pans connected with each other by a suitable vitrified or cast iron pipe at the bottom of the pan or bowl, and forming one piece with it. At the end of the last section a discharge valve is placed, being an upright pipe in which a plunger works, the latter being hollow so as to serve also as an overflow. As the plunger closes the outlet tightly, water is held back in the latrines to the height of the overflow in the plunger. The plunger or discharge valve is under control of a janitor, who raises this plug as often as found neces-

sary to empty and clean the latrines. The water then rushes out of all the bowls with great force and in great quantity and everything is effectually carried out of the plunger chamber and trap underneath. Moreover, each bowl is provided with a supply pipe to rinse its sides each time the plug is raised. As soon as the plug is dropped, the bowls and connecting pipes fill with water and are, in a few moments, again ready for use. The bowls are generally formed so that no excremental matter can strike their sides; everything drops at once into water and is partly deodorized. The only part which may get foul in time is the plunger chamber, although this is not as likely to occur with latrines as with a single plunger closet.

Trough water closets are constructed in different manners, generally of brickwork with vertical side walls and round bottom, but sometimes of iron, holding a large quantity of water, with the bottom of trough inclined to the end, where the discharge plug is situated,

and with a single or double row of seats placed above them. They are somewhat less expensive than latrines, and fulfil, in some cases, a good purpose.

A good substitute for latrines and trough closets may be found in a number of flushing rim all earthen hoppers such as Rhoads', Hellyer's, Demarest's, Huber's or the Niagara Hopper, with wooden rim attached to the bowl as a seat, each provided with a trap and flushed automatically either by Field's annular siphon tank or McFarland's tilting tank, as often as desired, the operation of emptying and flushing the closet being thus made entirely independent of the carelessness or forgetfulness of the persons using the closet.

GENERAL ARRANGEMENT OF WATER CLOSET APARTMENTS.

In speaking of plumbing fixtures in general I have decidedly condemned the usual manner of encasing fixtures with tight woodwork. While this is objectionable with any kind of plumbing ap-

paratus, it is even more so with water closets. With a tightly boxed-up water closet ventilation is impossible under the seat; the frequent cleaning of the apparatus is neglected, the floor often becomes wetted with urine drippings or water spilled in carelessly using the closet as a receptacle for slops; the filthy liquid soaks into the absorbent floor, which constantly remains damp and emits unpleasant odors into the apartment.

As an abundant supply of water is most essential to the interior of the bowl and closet, so is plenty of light and air indispensable to the outside of the closet. A water closet should stand free on the floor, readily accessible on all sides. The only woodwork necessary is the seat; this should be without a cover and can be hinged and leaned against the rear or side wall, when the closet is not in use. Such an arrangement looks especially neat where the floor is laid in tiles, and if the water closet is entirely of white crockery ware, for instance a

long or short flushing rim hopper, or an earthenware wash-out closet.

Col. Geo. E. Waring, Jr., thus describes such an arrangement: a closet, "made of white earthenware, and standing as a white vase in a floor of white tiles, the back and sidewalls being similarly tiled, there being no mechanism of any kind under the seat, is not only most cleanly and attractive in appearance, but entirely open to inspection and ventilation. The seat for this closet is simply a well-finished hardwood board, resting on cleats a little higher than the top of the vase, and hinged so that it may be conveniently turned up, exposing the closet for thorough cleansing, or for use as a urinal or slop hopper. Such closets ought entirely to do away with the use of urinals in private houses, and if, for convenience or to prevent the possibility of baths being improperly used, separate slop sinks are desired, these should be constructed like the hopper closet, the outlet being protected with a

movable basket of wire cloth made for the purpose."

The arrangement suggested adds, of course, to the expense of a water closet, but, where white Minton tiles should prove too costly, a plain cement floor, or slate, or else enameled tin may be substituted for them. A tight hardwood floor is well suitable, and may be covered, if desired, by oilcloth.

Wherever woodwork is used for the sake of better appearance of closets having mechanical parts (plunger closets, valve closets), at least the riser should be arranged with lattice work or a great number of perforated holes to provide ventilation under the seat.

It is desirable to locate water closets near an outer wall, in order to give the apartment ample light, and a window opening on the exterior of the house, for ventilation. Where such an arrangement cannot be secured—and it is seldom possible to do so in American city dwellings—the apartment should have borrowed light and special means for its

ventilation should be provided. A dark, unventilated, narrow space for a water closet, opening into a dressing room, or situated off a staircase landing, or even close to sitting rooms, is an abomination. In England water closets are "constructed inside a house with an intermediate vestibule, with a cross-current of air, so as to cut off the air in the house from that in the closet." The rigor of the climate in our Northern States forbids such an arrangement, but in moderate climates it is quite practicable to locate water closet and slop sink apartments in a tower connected to the main building by a passage or hall, which, however, is separated from it by double doors, the hall being efficiently ventilated by two windows on opposite sides. If located in the center of the house such apartments need sometimes artificial lighting by gas, in which case the heat of the gas flame can be utilized to create a constant draft and thus to ventilate the closet apartment by means of tin or galvanized iron pipes,

extended—independently for each apartment—through the roof. Fresh air should, in such a case, be supplied to the room, either by blinds in the door, or else by cutting away its lower two or three inches.

Sometimes in order to remove noxious gases generated in using the closet, a special vent pipe is attached to the closet bowl, leading into a constantly heated flue, used for this purpose *only*; or else an upward draft is created in the vent pipe by connecting it with a chamber, in which a gas jet is burning, and the outlet pipe of which enters the flue, or extends up to the roof. Such a venting of the closet bowl is provided, for instance, in the Zane plunger closet, in R. D. O. Smith's "Odorless Hopper Closet," in the "Worcester Hopper," Maddock's "Inodorous" Hopper, Moore's "Sanitary" Water Closet, Huber's hopper, with vent pipe attached to bowl, Watson's hopper, Mott's ventilated hopper, Harrison's "drip tray bowl hopper, and others.

Sometimes such a ventilation is applied directly under the seat, by using an annular flat zinc tube, provided with a number of openings at the inner edge, and connected to a special flue.

It would be a serious mistake to run such vent pipes into a kitchen flue, and far more so to run them into any other chimney of a building. There is at times a downward draft in these—even in the kitchen flue, the fire of which may go out over night—and thus offensive gases from the closet would be carried into the house. Another reason against such a course is that small vent pipes would soon become obstructed by soot. The best course, where a special flue has not been arranged, is to run the vent pipes along some heated flue up to the roof, and terminate their ends at a point where they are well exposed to the currents of air. These remarks apply also to the vent pipes of containers of pan or valve closets.

It would almost seem superfluous to state that vent pipes from closet bowls

should never enter a soil or waste pipe, or a vent pipe from traps. But such cases are not rare, and an instance of such pernicious practice—which should be considered either as criminal carelessness or else as utter stupidity and inability of the mechanic—was related to me only a short while ago.

While speaking of the proposed use of kitchen flues for vent pipes of closet bowls or containers, I might mention the fact that it has repeatedly been proposed to utilize the heat of the kitchen chimney for the ventilation of soil pipes, by running these from above the highest fixtures into such heated flue. Such practice is not permissible under any circumstances whatever, for there are at times downdrafts, which would force soil pipe air into the house. Besides this, it is well known that bricks absorb gases, and would thus in time become impregnated with sewer gas.

For public places, such as railroad depots, schools, colleges, hotels, etc., where water closets are likely to be used

in rapid succession at certain times of the day, a *special ventilation of the apartment* is necessary, even where windows are provided, to remove offensive smells from the use of the closets, which may arise, however well the closets may be trapped and the pipes ventilated. It would lead too far to consider in detail the best means for ventilating such apartments. Suffice it to say, that providing only an exit for the foul gases cannot be regarded as *ventilation*. To preserve the purity of the atmosphere in such apartments it is necessary to introduce a sufficient quantity of pure air, moderately heated in winter time, and to provide an outlet for the foul air. A much disputed question in locating this outlet is whether it should be near the floor or near the ceiling. The former may have advantages from an economical point of view, but from a sanitary point of view, which should only be taken into consideration in the ventilation of such apartments, I should always advise locating the outlet near the ceiling of the room.

No amount of ventilation, however, will keep the air of the apartment pure unless the water closet is frequently and thoroughly washed and scrubbed. Such cleansing is much facilitated with the above suggested arrangement of a water closet.

The following valuable remarks of Mr. Edward S. Philbrick upon this subject so fully express my own views, that I quote them *in extenso*: "The location of plumbing fixtures in dark corners, under stairways and in closed closets is always to be avoided. Such fixtures, even if of the best materials and design, need frequent washing and even scalding to keep them sweet, and the more light and air can be admitted to them, the more likely will the occupant be to enforce such cleanliness. The best authorities in England recommend the location of water closets outside the house walls, in towers or outside appendages. The rigor of our climate forbids such an arrangement in the Northern States, but they can often be so placed near the

outer wall of the house as to allow of a window for the direct admission of light and air, *i. e.* in the same apartment. This can be done in all suburban houses without an undue sacrifice of light in the living and sleeping rooms, though city houses can rarely afford anything better than skylight and well light for them. . . . The water closets on the basement floor are generally the source of much trouble by injudicious location and subsequent neglect. The rareness of the inspection generally given to such fixtures by heads of families renders it all the more needful to place them where they can be readily and easily cleaned and well aired. . . . But however good the apparatus and however well located, nothing will compensate for *neglect* by the occupants of the house. Frequent applications of hot water and soap are just as needful to the surfaces of such fixtures as to the bodies of the persons who use them. Of course the woodwork about them should be so put together as to be

readily taken apart without tools' by any house-maid, to be periodically cleaned and aired. What is the custom in this respect? Expensive apparatus is often seen so boxed up by screwed and even *nailed* joinery, that the spaces so enclosed are practically inaccessible and soon become abominably foul from splatterings. The less amount of woodwork the better, but by all means have the whole so as to be ready of access without the need of so much as a screw-driver, and let every house-maid be taught the necessity of a regular routine in the cleansing operations, scalding and scouring every surface which has been exposed either to the splattering of urine, or even to the perspiration of the body. It may not be always possible to enforce such discipline, but the less it is enforced, the more important become the items of light, air and simplicity of construction, as aids in the same direction. The latter are generally under the control of the architect, and his mistakes of planning entail a *per-*

~~manant~~ and incurable evil, which it is therefore all the more important to avoid. . . . While every aid should be given to cleanliness by simplifying the apparatus, no amount of perfection in this respect will avoid the need of constant thought and care on the part of those who use the fixtures, as well as those whose duty it may be to cleanse them. Such perfections of apparatus are but aids, and though not to be ignored by any means, are after all but of little avail if the people who use them are reckless and wanton in their habits. It is difficult enough to keep such apparatus in good order in private houses where not used by any one beyond the supervision of the head of the family, but the trouble increases in a manifold ratio where fixtures are applied in hotels or public places, or in tenements to be used by more than one family."

FLUSHING APPLIANCES.

Flushing tanks should be provided in a system of house drainage, whenever it

is impracticable to lay the drain at an inclination which will secure a sufficient cleansing flow. The idea underlying most of these flushing arrangements is the accumulation of a small flow of water—often merely a dribble—which continuously running, at a sluggish rate, would not be able to remove deposits in the drain. Whenever this water has accumulated to a large volume, the flush tank is automatically emptied and its contents are driven with a sudden rush through the drain. As this may be repeated as often as found necessary, the inside walls of the drain may be kept thoroughly cleansed, and any decomposition of organic matter is thus effectually prevented.

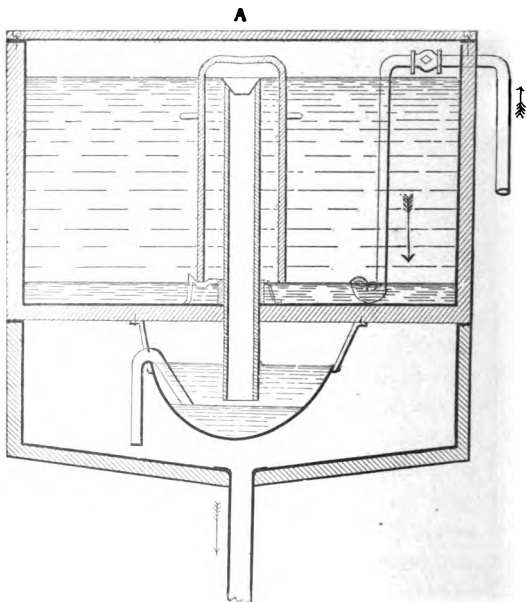
Automatic flush tanks are likewise frequently used for flushing a number of water closets, urinals or slop sinks, and even a single water closet, if in an exposed locality, where the water in the supply pipes would be apt to freeze unless kept constantly running. It has been already stated that such continually

running dribblets are unable to produce an effective flush, but, by collecting the dribblets in a flush tank, discharging automatically, when filled, the desired purpose may easily be accomplished.

There are many varieties of flush tanks, such as Field's siphon tank, McFarland's tilting tank, Shone's flush tank, Maguire's, Rhoads', Hydes', Ivers', Wilson's, Guinier's tanks and others.

Field's flush tank, the invention of the well-known English engineer Rogers Field, has been used with success in this country. One of his tanks has a common siphon, and is started only by a sudden addition of a larger quantity of water. The other tank is provided with an annular siphon, the outer and inner limb being concentric. This tank is started by a small trickling flow. It may be constructed of small size, to flush a row of hopper closets or urinals automatically. Larger tanks are used for flushing house drains and town sewers, and are also adapted for sewage disposal by surface or sub-surface irrigation.

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FLUSH

A Siphon tank.

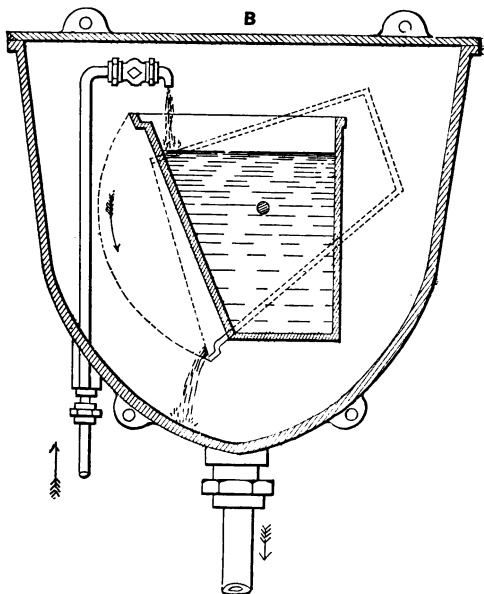
**TANKS.****B Tilting tank.**

Fig. 6, A, shows a Field's flush tank with annular siphon, the tank being of wood lined with sheet lead. The longer inner limb of siphon reaches into the trapping box suspended underneath, in which the water level is kept about one-sixteenth of an inch below the end of inner limb of siphon by means of the second "auxiliary" siphon. The working of the tank is as follows: As soon as the water from the faucet has filled the tank so that the water rises to the top of the longer (inner) limb of siphon, it commences to overflow, but is guided by a conical-shaped adjunctage to drop clear of the sides, and seals the mouth of lower limb. In falling, the water carries air with it, which is thus displaced and driven out at mouth of inner limb in trapping box. A slight vacuum is gradually created in the discharging limb, sufficient to start the siphon, which rapidly empties the tank. As soon as air is admitted through the outer (shorter) limb of siphon its action is stopped, all the water in the inner limb drops into the water chamber, and the

auxiliary siphon lowers the water line in trapping box about one-sixteenth of an inch below the mouth of inner limb. Air enters at this place and completely breaks the siphon; the tank is then ready for another discharge. The stopcock can be regulated to fill the tank more or less rapidly according to option.

McFarland's tank is shown in Fig. 6, B. It works by gravity, and is simply a bucket hung in a cistern, working in brass journals. As soon as filled from a faucet regulated to let the water in slowly or quickly as desired, the bucket tips over and empties the entire contents at once. This tank is well adapted for flushing closets, slopsinks and urinals.

I have endeavored, in this volume to explain what means and devices should be used, and what rules must be followed, speedily and safely to remove by the water-carriage system all liquid and semi-liquid wastes from habitations. The all-important question of how to dispose of the waste matters of the household in

the *safest*, least disagreeable, most efficient and most economical manner has not been referred to.

The discharge of sewage into water-courses or into the sea, its treatment by chemical processes, filtration of sewage; surface and sub-surface irrigation, intermittent downward filtration of sewage, the processes of dry removal, by pail or tubs, earth closets, ash closets, cesspools, privies, vaults, manure pits and kindred subjects, the removal of garbage, kitchen slops, ashes, etc., in other words, "*The Disposal of Household Wastes*," will be made the subject of a future volume.

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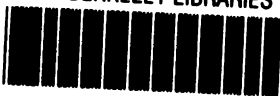
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